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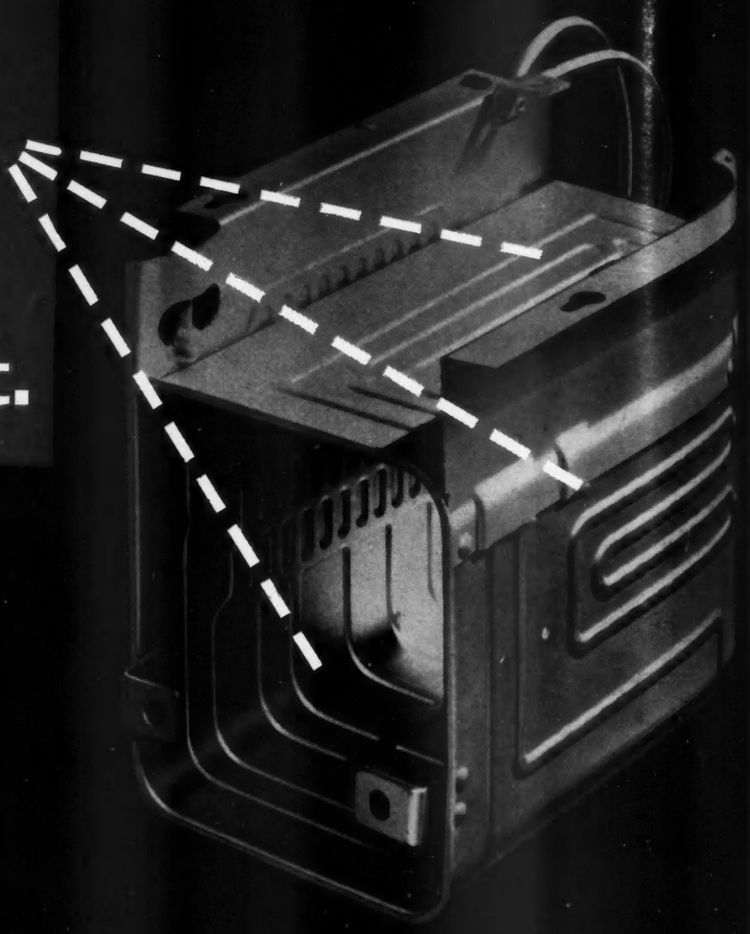

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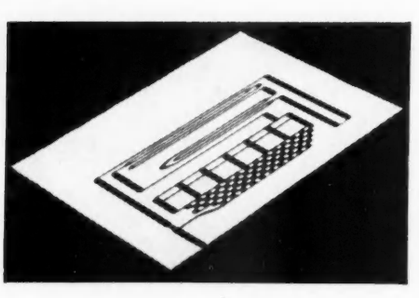

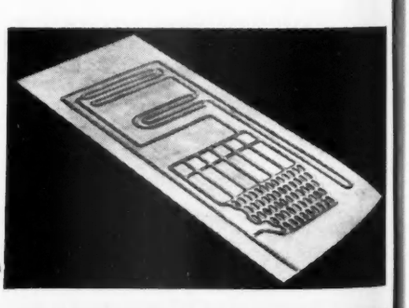

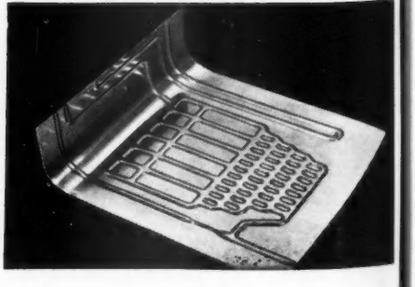

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ENGINEERING

An Illustrated Weekly Journal

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LOOK BACK IN PRIDE

It will probably be our children, or our children's children, who will honour the end of the steam locomotive in active service. The British Transport Commission have said that they propose to build no new express passenger or suburban steam locomotives after this year's programme, and to terminate the building of all new steam locomotives within a few years. But locomotives are long-lived: there will almost certainly be a few still busily shunting when we are laid to rest. Maybe it is a merciful dispensation that we shall not be alive to attend the sad ceremony, but at least we can look back on the many experiments that have been made to improve the steam locomotive, especially since electric traction first threatened, about 1885.

Mr. C. R. H. Simpson has made a special study of these numerous experiments and the first of a number of articles by him appears in this issue. He excludes all modifications which have become accepted, such as the smoke-tube superheater and articulated designs like the Beyer-Garratt. It is remarkable that the steam locomotive, in spite of all the experiments, has conformed fundamentally to the Stephenson design—a fire-tube boiler and direct drive from cylinders to crankpins. Steam turbines, water-tube boilers, geared drives, electric transmission, and the combination of internal and external combustion—these and many more besides have been tried and have failed. The only permanent and radical improvements in design have been the introduction of the brick arch and of superheated steam.

Experiments have not been the prerogative of the larger railway companies. Many of the smaller companies were equally progressive; for example, the Maryport and Carlisle and the North London Railways were among the early users of steel fireboxes. There was a time when designers' efforts the world over were concentrated on compounding. Concurrently to some extent with the compound era was the cult of the big boiler. Later, streamlining was the order of the day. Fashions prevailed, too, in wheel arrangements, particularly in the introduction of the Atlantic and later in the large-scale reversion to the four-coupled engine for working light high-speed trains in the 1930's. The ultimate aims were, at different times, higher power, higher speed, and maximum availability. Always there was the desire to produce a machine that would be economical to operate. At the turn of the century the Caledonian Railway were getting a ton of coal for 5*s.* 4½*d.*

Many of the ideas aimed at increased thermal efficiency succeeded in their object, but the price paid, both in increased capital cost and increased maintenance, offset the gain and in some cases there was the added source of potential failures. Railway officers did not look kindly on experiments which, if they failed, could stop the flow of traffic on the railway for a large part of the day. The steam locomotive may have thrown a lot of its fuel out of the chimney unburnt, but it would stand up to gross overloading, it would keep running though it was in poor shape mechanically, and it could be made to reach its destination on time.

Many inventions were before their time. Typical of this was the cast steel frame. A patent for such a frame, embodying horns, cross stays, etc., in a single casting, was taken out by F. W. Webb in 1869. Fifty-six years were to pass before the cast steel frame was forced on American builders by the difficulty of maintaining large cylinders tight on the frames.

In many instances credit for ideas introduced within recent years can be traced back a long way, though even had the need existed—as indeed it did in some instances—the original ideas could not have been satisfactorily employed for metallurgical or other practical reasons. A thermic syphon welded to the firebox plates is a much more attractive proposition than a Tenbrinck arch connected to the firebox sides through flanges and studs.

Comparison of the locomotive of 1900 with the modern locomotive shows that surprising progress has been made—this despite numerous assurances that by the end of last century the steam locomotive had reached the limits of its development in every respect save length. Contrary to practice in many other fields of endeavour, the older established the steam locomotive became the greater was the effort to improve it. These attempts reached their zenith between the two world wars, with the increased competition of electric and Diesel traction. The desire to improve performance was by no means limited to new locomotives; much was—and is still being—done to improve the performance of existing locomotives. When the chapter is closed and the full history can be written it may well be that the magnificent testing equipment which only became available during the steam locomotive's later life will have proved of greatest benefit in showing the way to improved performance from existing designs. Already several instances have been recorded, in the valuable bulletins issued by British Railways on performance and efficiency tests conducted on the road and the Rugby and Swindon plants, where comparatively minor alterations have had far reaching influences on the results obtained.

Chief mechanical engineers and other locomotive engineers at the trials of a Sentinel engine in 1934. The group includes Sir Nigel Gresley, Sir William Stanier, Mr. O. V. S. Bulleid, Mr. Julian S. Tritton, Mr. J. Clayton, Mr. H. V. Gaud and Mr. F. W. Hawksworth.

Plain Words

Since the war an average of 120,000 men and women a year have left Britain to settle permanently in the Commonwealth. Some of them have made their own arrangements but the great majority have gone under passage schemes run by the Commonwealth governments.

By the end of 1955 Canada had taken 1,200,000 people of all nationalities since 1946—an increase in population of 10 per cent. Canada's policy has been to recruit skilled workers under a loan passage scheme. Even so it has not been possible to maintain the percentage of British stock in the Canadian population. By the end of the century it will have fallen from 47 per cent. to 32 per cent. Australian policy is to take immigrants from Britain wherever possible. The present target is a total of 125,000 people a year.

New Zealand is operating a free passage scheme giving preference to United Kingdom immigrants. Of the 186,000 post-war immigrants 102,000 have come from Britain. A post-war population increase at the rate of 2 per cent. a year has put a considerable strain on the New Zealand economy and the authorities have therefore reduced the annual intake to 20,000. The Federation of Rhodesia and Nyasaland is now taking some 26,000 immigrants a year.

The report of the Overseas Migration Board (Cmd. 9835) estimates the total requirement for the four dominions to be between 150,000 and 200,000 immigrants from the United Kingdom each year. Apart from Canada the main limiting factor at the receiving end is lack of capital to provide the public services, machinery, buildings and other amenities the settler has known at home. The expenditure has been put at £2,000 to £2,500 for each immigrant. This connection between immigration and capital investment must be remembered by all who want to see emigration to the Commonwealth maintained.

THE EXPERIMENTAL SPIRIT

1—LOCOMOTIVE BOILER DESIGNS THAT FAILED

By C. R. H. Simpson, A.I.LOCO.E.

For over fifty years locomotive engineers whose affections lay with the steam engine have fought for its survival. They were confronted with the obvious advantages of electric and then Diesel traction, but they believed that, on balance, the steam locomotive could win. In Britain the battle is at last over—the modernisation plan for British Railways states that no more steam locomotives will be built after a few years. Those that are left to grow old are basically of the same type as Stephenson's Rocket: virtually all the major departures of design that have been tried out experimentally in order to make the steam locomotive more competitive have failed to justify the hopes that were placed in them. Details of these experimental designs were usually published at the time, but the reasons for failure were seldom recorded. Some of the reasons may never be known. But as far as possible the author of this series of articles has collected the evidence and presents it briefly here, with notes on the designs.

Though the Stephenson form of boiler necessitates considerable maintenance and repair work, as compared with other types of boilers used in other practice, its output is phenomenal for its size. To obtain up to 3,500 cylinder horse-power from steam supplied by a boiler fitted into the confines of the British loading gauge, or up to 8,000 h.p. in the case of American practice, is a remarkable performance. Any other type of boiler made to a similar size and shape has proved to require higher maintenance.

Even had some of the "improved" designs proved beneficial from the point of view of steaming, they must have been ruled out of court on a maintenance basis. A good illustration of this was Drummond's boiler containing a large flue fitted with cross tubes; little maintenance work was possible on these tubes unless the large flue was withdrawn from the barrel.

There have been many efforts to get away from the water legs of the conventional boiler, which having flat surfaces are always a source of potential trouble. The water-cooled legs, however, were one of the reasons for the success of the Rocket's boiler. Sometimes an attempt has been made to replace the whole firebox by one of another form, while less drastic methods have been the substitution of firebrick walls for the legs.

An early attempt to dispense with the water legs of the Stephenson firebox was that made by Verderber of the Hungarian State Railways, who, in 1878, replaced the two side legs with a fireproof lining.[1] The object was to cut-down high firebox maintenance resulting from very bad water. This gentleman's knowledge of the Stephenson boiler appears to have been somewhat hazy as his considered opinion was that "the firebox as a steam generating part of the boiler is superfluous." In fact, the firebox takes up perhaps 40 to 50 per cent.[2] of the total heat absorbed, the percentage being dependant upon the combustion rate.

Attempts to replace the legs include the substitution of the orthodox firebox by a circular one—as done by Lentz on the German railways, H. A. Hoy on the Lancashire and Yorkshire Railway in 1902 and again by the German railways during the second World War. The experiences, despite metallurgical progress in the intervals, were much the same.

The Krauss stayless boiler was fitted to a number of German locomotives during the second World War, and made a considerable contribution to simplifying construction and reducing labour costs. The usual firebox was replaced by a corrugated drum formed from a rolled plate welded longitudinally. The method of welding and assembly of the boiler had several features of interest, including the insertion of the inner firebox through the throat-plate opening.[3]

The Vanderbilt firebox[4] was a circular one applied to some oil-burning locomotives on the Southern Pacific Railroad. In the Player boiler[5] three circular tubes, 28 in. in diameter and 84 in. long, each housing an oil burner and connected to common chambers at the back and front ends, replaced the orthodox firebox. In the case of circular fireboxes the back was sometimes wet—as in the Krauss boiler—and sometimes dry with a firebrick lining outside, as, for example, in the Vanderbilt firebox. The Vanderbilt firebox lacked sufficient grate area and firebox volume to cope with the high rates of combustion required and was soon discarded. Circular fireboxes have, of course, been used for many

years on industrial and contractors' locomotives of the smaller types, and were also used by F. W. Webb on L.N.W.R. shunting locomotives. They have attractions on engines of limited boiler output, one of the chief advantages being ease of replacement when the back was a dry one.

Other attempts to replace the orthodox firebox were limited to substituting firebrick for the legs while retaining the crown section. The removal of legs not only radically alters the circulation taking place in the barrel but has also the effect of producing excessively hot footplate conditions. Adequate circulation is essential to free steaming and freedom from boiler troubles. Churchward, who made a point of allowing adequate circulation around the firebox, attributed three-fourths of all tube troubles in large boilers to neglect of this point.[6] It is of interest to note that some devices, such as a mid-feather (an additional water leg on the longitudinal centre-line, not always the full depth of the firebox), and cross-tubes in the firebox, while improving steam generation, were primarily introduced with a view to improving circulation. Probably the poorest circulation was that of Webb's fireboxes, where due to lack of circulation it was possible in cold weather to get icicles forming on the underside of the firebox.[7]

A well-known British experiment to replace water legs was that of Paget on the Midland Railway. In his 2-6-2 locomotive—which embodied many departures from the Stephenson form—the sides and back walls of the firebox were constructed from firebricks having a thickness of 6 in. A firebrick cross-bridge at the front of the firebox, 9 in. thick, was arranged to deliver heated air to the combustion chamber. This boiler, which was fitted with Serve tubes (described later), made ample steam on test.[8]

The last British attempt to dispense with the water legs was that made by Mr. O. V. S. Bulleid in his "Leader" Class. In this engine the normal firebox was absent; instead, four thermic syphons were fitted in conjunction with a round-topped drum and an orthodox barrel. The whole was of welded construction. The heads of the syphons were attached to the underside of the drum and the necks to the underside of the barrel.[9]

Serve boiler tubes have had a wide application on the Continent but have not been favoured in Britain, although they were used to a limited extent on the Great Western Railway. They are difficult to clean and involve extra work in expanding; they are, of course, also more costly than an ordinary tube. The presence of the gills makes them very rigid and it is considered by some that the tube-plates consequently suffer. Theoretically, the Serve tube greatly increased the heating surface. A tube of 2¾ in. outside diameter with eight gills had an inside area of nearly 15 sq. in. per inch of tube length. Results obtained on test showed that the heating surface of the Serve gills was "not equal to ordinary tube heating surface in capacity."[10]

This is an example of a modification which may initially show beneficial results but which are not sustained—in this case due to the cleaning difficulty. F. W. Webb employed a fluted tube but abandoned it due to excessive abrasion.[11]

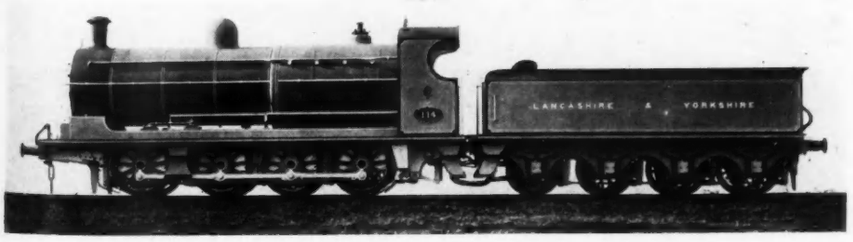
"Ess" tubes have been fitted to a number of Swedish locomotives. They originally took the form of a tube having a simple helix of small depth running throughout its length. Trouble was experienced due to soot and dirt accumulating in the groove, from which it was removed with great difficulty. Later, three raised waves were introduced and some reliance was effectively placed on the rotary motion of the gases to keep the tube clean. Some economy in fuel is stated to have resulted from the use of these tubes as a consequence of more intimate contact between the gases and the tube wall, but probably the greatest benefit accrued from the spark-arresting qualities they possessed as a result of cinders being disintegrated in their passage through the tubes. Owing to increased resistance to gas flow these tubes necessitated a decrease of the order of $\frac{3}{8}$ in. in the diameter of the blast orifice. Helical superheater elements housed in plain flues have also been used in conjunction with "Ess" smoke tubes. A claim for an improvement in boiler "results" of about 5½ per cent. was made at one time for the combination of "Ess" tubes and helical elements.

A modification which increased an engine's capacity for work by 10 per cent. for a given coal consumption was of infinitely greater interest to the running department of years gone by than one which gave the ability to perform on a coal bill reduced by a similar amount. To-day, when locomotives are usually masters of the situation they are called upon to handle, it is worth recalling the prodigious feats of such locomotives as the L. & N.W.R. "Georges," capable of regularly and punctually handling trains of seven times their own weight.

SECONDARY AIR

British designers have usually been content to supply secondary air to the firebox via the firehole but there have been some exceptions to this practice. In Ramsbottom's time there were two openings, fitted with dampers, in front of the firebox above the level of the fire.[12] Circular openings for this purpose were provided through the water legs of many locomotives, e.g., Beyer-Garratt locomotives used on the L.M.S.R. Dean of the G.W.R. used secondary air openings at the base of the combustion chamber on his 2-6-0 design, ingress being governed by butterfly valves of about 8 in. in diameter. It appears that this led to trouble with the wrapper plate as the design of this plate was subsequently altered and the drawing of the replacement shows the use of corrugations. In the case of circular openings through the water legs, the control of air entering the firebox could be either by a manually-operated valve, as used by Dean, or it could be related to cut-off, as in the case of the "Acme" fuel economiser where the amount of opening was determined by the position of the reverser.

In American practice openings have also been provided. Though in some cases, where grates were large, this practice was beneficial to combustion, considerable noise resulted from the ingress of air through the openings and this was of sufficient volume to be objectionable when standing in or near stations. The amount of air required is large: in the case of an engine burning 15,000 lb. of coal per hour it is about 2¼ million cub. ft. per hour.[13] In the case of a hand-fired engine working hard, the firehole door is open to such an extent for firing purposes that adequate secondary air can usually enter. Uncontrolled secondary air can lead to high losses due to incomplete combustion.



Lancashire and Yorkshire locomotive with circular corrugated firebox.

So far as the writer is aware, only one application has ever been made of a pressurised ashpan to a locomotive (G. A. Nichols' "Novelty" of the Philadelphia and Reading Railroad). This was probably the greatest mistake ever made in locomotive design, for as pressure was derived from an axle-driven fan the firedoor could only be opened when the engine was stationary. In locomotive practice a pressurised ashpan could never replace the blast-pipe as the pressure needed to force the products of combustion through the tubes would be so high that the fire would be forced off the grate.

Corrugated fireboxes of otherwise orthodox shape have been applied. The use of corrugated firebox sheets has the advantage that the box can be designed to take up expansion in the principal direction, i.e., lengthwise, without subjecting the stays to bending stresses.[14]

An example of a corrugated box was the Jacobs-Shupert introduced in American in 1909. The inside wrapper of this box was constructed of a series of channel-section pressings, arched to form the firebox crown and sides, which were riveted together. This form of construction proved to be too rigid and its use was not perpetuated due to trouble with leakage at the riveted joints. At this period boiler explosions were commonplace in America; in a report issued by the Atchison, Topeka and Sante Fe Railway on tests carried out with this firebox, it was stated that "there is never a month without a bad boiler explosion." A claim made for the Jacobs-Shupert firebox was that "if it did blow up the results would not be disastrous"! Tests carried out by Dr. W. F. M. Goss, of the University of Illinois, established that there was very little difference in evaporation between the Jacobs-Shupert firebox and a conventional radially-stayed one.

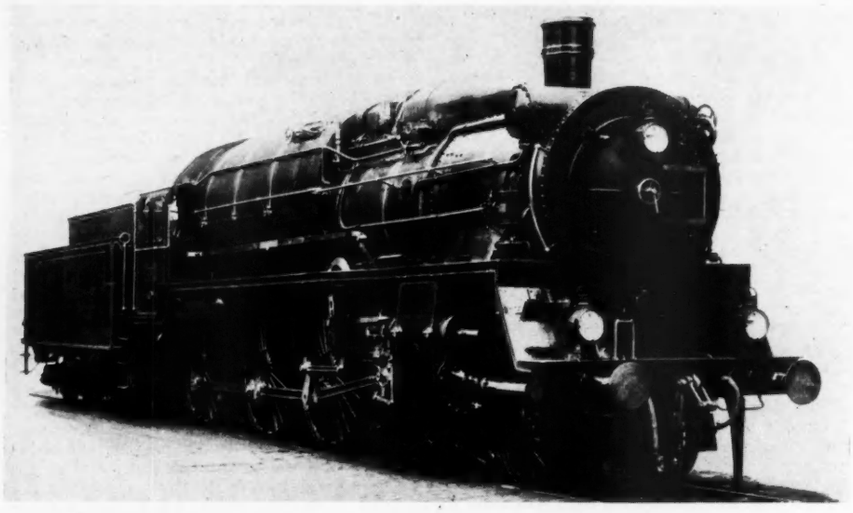
In the Gaines firebox as fitted to an American 2-8-8-2 Mallet locomotive,[15] the brick arch terminated at the front end against a transverse brick wall located some 5 ft. away from the firebox tube-plate. In front of the wall was an opening which served the dual purpose of an exit for ashes and an entry for secondary air.

The boilers on some Mallet locomotives reached enormous proportions. That for a 2-8-8-4 on the Northern Pacific R.R. had a length of some 64 ft. and empty weighed nearly 74 tons; measured inside the firebox it was 9 ft. 6¼ in. wide and 22 ft. 2⅛ in. long. The mechanical stoker was capable of handling 20 (U.S.) tons of coal per hour. An interesting aspect of mechanical firing was that sometimes a firebox of about 50 sq. ft. grate area which gave satisfactory results when hand fired, if fitted with a mechanical stoker, had insufficient volume to cope with the combustion of the larger quantity of fuel delivered.

To overcome the difficulties normally associated with fire-tubes, D. Drummond hit upon the idea of replacing all the tubes by a large single flue having cross-tubes at approximately 90 deg. to each other. The idea was not perpetuated—which was not surprising in view of the maintenance difficulties already referred to. D. Drummond also favoured cross-tubes in the firebox, and while those were claimed to achieve a fuel saving of 5 lb. per mile the saving was not considered sufficient to warrant the considerable extra first cost and maintenance costs. But at that time (1898) coal was costing the L. & S.W.R. only 13*s.* 6¼*d.* a ton. To employ cross-tubes effectively a deep firebox is a necessity and, when Drummond was carrying out his experiments with water tubes, deep fireboxes were not the order of the day. Drummond's cross-tubes were liable to a peculiar form of pitting in the form of pinholes, probably caused by sulphurous gases emitted from the coal.[16]

While Drummond's application of firebox water tubes is the best known, it was preceded, though in a considerably simplified form, by Smith of the North Eastern Railway on his experimental three-cylinder compound No. 1619.

Water tubes later reappeared in the guise of arch tubes, circulators and thermic syphons, all



Schmidt-Henschel high-pressure boiler on a German three-cylinder locomotive.

of which were fairly close relatives of the mid-feather. Apart from circulator tubes all of these devices considerably increased the firebox heating surface. In the case of syphons this increase could be from 15 to 45 per cent., depending upon the size of the firebox.

WATER-TUBE BOILERS

Water-tube boilers as applied to locomotives may be divided into two classes: (1) those in which a water-tube firebox was employed in conjunction with a normal type of barrel, and (2) those in which a water-tube firebox was used in company with a special type of barrel. While latterly water-tube boilers have come to be associated with high pressures this has not always been the case, but it was the demand for higher pressures which led to the comparatively extensive development of water-tube boilers for locomotive use in the 1920's and 1930's. Of the many types developed the only one to survive is the well-known Sentinel boiler. Though this boiler is most successfully employed on industrial locomotives, it has definite limits of size, being arranged vertically, and is not within the orbit of this review.

The Woolnough water-tube boiler was fitted to the Sentinel locomotive illustrated on page 610. It consisted of one steam drum and two water drums connected by two banks of tubes and was in effect all firebox! It had good features, included among them being relative accessibility, but so far as locomotive applications were concerned it had limitations of size.

The Brotan boiler took two forms: in both instances a water-tube firebox was employed but whereas in one form the barrel consisted of two cylindrical drums, the lower one of which was fitted with flues, in the other instance one larger diameter shell was employed. The only known British application of this boiler was to an industrial locomotive, built by Beyer, Peacock and Company, Limited, but on the Continent a large number of engines were built with Brotan boilers for the Austrian, Hungarian, Prussian, Swiss, Russian and a variety of private railways. This form of firebox was the forerunner of a number of later ones which were basically similar. While the design was one which readily lent itself to high pressures, no attempt seems to have been made to exploit this possibility, e.g., a 4-6-0 locomotive built for the Swiss Federal Railways in 1908 carried a Brotan boiler pressed to 220 lb. per sq. in.

Water-tube boilers, so far as working pressure was concerned, fell into three categories: (1) those which worked at the normal working pressure of the Stephenson boiler; (2) those designed primarily to work at higher pressures, e.g., 500 lb. per sq. in. Delaware and Hudson R.R. "James Archibald," and 800 lb. per sq. in. as in the Winterthur locomotive built in Switzerland in 1928; (3) types produced for ultra-high pressure such as the Schmidt double-pressure design and the Löffler generator working at 900 lb. and 1,500 lb. respectively. Normally the Stephenson boiler is not pressed above 250 lb. per sq. in.; but there were exceptions, e.g., the use of 325 lb. in a normal boiler by the Delaware and Hudson R.R. and the employment of 300 lb. in the orthodox boiler fitted on the Beyer-Peacock turbine locomotive used in Britain. In the 1930's a considerable number of water-tube boilers were produced;[17] among these may be mentioned the Schmidt Henschel for German, French, and American railways and the Winterthur high-pressure boiler. High-pressure boilers—from 300 to 500 lb. per sq. in.—were of watertube form but had a feature in common with the Stephenson form of boiler, i.e., evaporation was the result of water directly absorbing heat from the furnace gases.

An example of a water-tube firebox in conjunction with a water-tube "barrel" was the Robert boiler[18] fitted to a 2-6-0 locomotive of the P.L.M. Railway in 1904. This gave some trouble owing to soot and ash deposits around the tubes, which necessitated frequent cleaning. Rapid circulation was relied upon to keep the insides of the tubes clean but in practice resort was had to hammering both furnace tubes and drum tubes to remove sediment. The working pressure was only 176 lb. sq. in. and the object of the designer was to overcome troubles experienced with broken stays, cracked tube-plates, etc., in an area where water was bad. This appears to have been one of the many cases where the "improved" design may have cured the original troubles, but a host of new ones were introduced. On balance the original form was to be preferred. After the Robert boiler had been tried on a number of locomotives, the solution ultimately adopted was to use orthodox boilers with treated water, which had the desired effect of reducing maintenance.

HIGH PRESSURE BOILERS

Sir Nigel Gresley's locomotive No. 10000, built in 1929, had a water-tube boiler produced in collaboration with Mr. Harold Yarrow. Although the boiler, which was pressed to 450 lb. per sq. in., gave a continuous evaporation of 20,000 lb. per hour for four hours under test, in service satisfactory steaming only occurred when the engine was developing high outputs at long cut-offs with a smokebox vacuum in the region of 6 in., at which figure the smokebox temperature was too high.[19] There were other troubles, e.g., difficulty in maintaining the boiler walls airtight, and despite sundry modifications and the fact that the engine was a compound, working—for a locomotive—at relatively high pressure, the coal consumption considerably exceeded that of a simple Pacific. The experiment terminated with the decision, in 1937, to rebuild the engine with an orthodox boiler.

The Gresley-Yarrow boiler had much in common with the Robert boiler and each was fitted to an engine otherwise of the Stephenson form. More often, water-tube boilers which had a water-tube barrel were fitted to locomotives of special types.

By using water-tube fireboxes, stay troubles were overcome; these—as everyone who has had experience with locomotive boiler maintenance is aware—can be considerable. A really large firebox, as encountered in American practice, could contain as many as 6,000 or more stays, involving the inspection and maintenance of 12,000 threaded joints.[20] On the other hand, the water-tube boiler, especially when the barrel was also of water-tube form, introduced special and serious problems in every instance.

The Löffler-Schwartzkopff ultra-high-pressure boiler was tried by the German State Railways. The products of combustion pursued a somewhat involved course, passing successively through a firebox composed of superheater tubes, a secondary high-pressure superheater, a reheater for the low-pressure steam, a high-pressure feed-water heater, and a pre-heater for combustion air. Evaporation took place by direct contact between intensely heated steam and the water in the vaporiser.

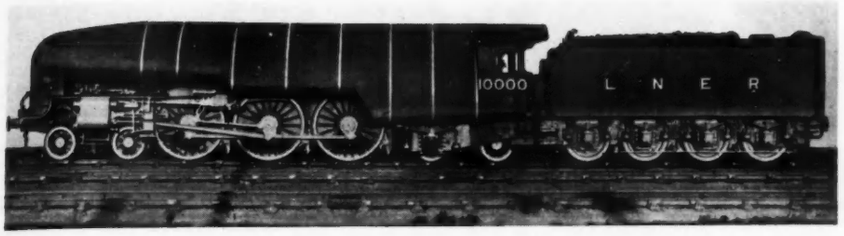
British trials with ultra-high pressure boilers were limited to those on the L.M.S.R., where one of the Royal Scots ("Fury," No. 6399) was fitted with a boiler of the Schmidt type. This boiler, also tried in France, Germany and America, generated steam on the Perkins' closed-circuit method and consisted of three distinct systems of boilers, each carrying a different pressure, the highest being 1,400 to 1,800 lb. per sq. in. in the closed circuit; steam was produced at 850 to 900 lb. per sq. in. Tests of this locomotive were concluded after a serious accident.

North American applications of the ultra-high pressure boiler, of the multiple pressure type, were on a locomotive of the New York Central R.R., and an engine on the Canadian Pacific Railway; neither saw much service.

Ultra-high pressure boilers, especially the multiple pressure ones, were complicated in design, costly to manufacture, and in some cases

Löffler high-pressure boiler on a German locomotive.

British "Royal Scot" locomotive with Schmidt high-pressure boiler.



Sir Nigel Gresley's high-pressure four-cylinder locomotive.

called for considerable precision in construction. The accessories were numerous and interdependent. This type of boiler was not an attractive proposition for a traffic machine whose primary requirement is dependability.

An advantage of the closed circuit was the rapidity with which steam could be raised. In the case of a 5,000 h.p. locomotive built by the General Electric Company in 1939 for the Union Pacific R.R., the amount of water in the boiler was less than 100 gallons, and as the boiler was oil-fired a few minutes sufficed to raise temperature and pressure from cold to full output.

In the case of the Velox boiler it was reported that 290 lb. per sq. in. was showing on the gauge within 15 minutes from cold. A Velox steam generator was fitted by the P.L.M. Railway to a 4-6-0 compound in 1937.[21] This boiler was developed by Brown Boveri and advantages were claimed for it on account of its small size, light weight, rapidity in steam raising and general adaptability. The fundamental principle was that combustion under pressure results in a great increase in the rate of combustion and the amount of heat released per unit volume of gas consumed. Owing to the high velocities of the combustion gases and the water of evaporation, the heat transferred by convection between the two fluids gave a far higher coefficient than that obtainable in an ordinary firebox by radiation. There was also an economy as a result of recovering a considerable proportion of the thermal energy in the gases by conversion into mechanical energy.

A feature of the Velox boiler is the small amount of water it contains within the evaporative elements, enabling it to respond rapidly to the fluctuations in demand which are characteristic of locomotive working. The absence of a blast-pipe enabled back-pressure to be as little as 2 lb., resulting in a gain of 170 h.p. at 75 m.p.h. on the particular locomotive.[22]

A disadvantage of this form of boiler was the number of auxiliaries required. The results obtained on the test plant at Vichy have been published.[23] Much of the development work put in hand—or about to be put in hand—in France was nullified by the last war. Of all the experimental locomotives ordered by the French Railways in the years immediately preceding the war, that with the Velox boiler was the only one which could be tested up to the outbreak of hostilities; 12,000 miles were run without failure. In this application the working pressure was 285 lb. per sq. in., determined by the existing cylinders of the original chassis used for the experiment.

WELDING

Although welding has been used extensively on both steel and copper fireboxes, its use on boiler barrels has been limited. While the view is not universally held, it is generally regarded as advisable to stress-relieve welded boilers; few furnaces are available capable of taking such a large component as a locomotive boiler. Radiographic inspection is essential. The application of welding to boilers generally—as distinct from the firebox—has been confined in Britain mainly to Mr. Bulleid's locomotives, although there have been a few other instances. The greatest use of all-welded boilers has been made in America (where there is an A.S.M.E. Locomotive Boiler Code dealing with welding) and in Czechoslovakia. In the latter country the view is taken that stress-relieving is unnecessary providing the work is adequately controlled and skilfully carried out. Although nearly 20 years have now elapsed since the first use of an all-welded boiler, on a Delaware and Hudson R.R. locomotive which ran well over half-a-million miles without any major repairs being necessary to the boiler shell, it is probable that the total number of all-welded—or almost all-welded—boilers is less than 100. The qualification "almost all-welded" is necessary as in the case of the Czechoslovakian boilers the joint between the firebox and barrel is effected by riveting to simplify firebox removal.

All-welded inner firebox by Beyer, Peacock for the Western Australian Railways.

The use of heat which would otherwise be discharged up the chimney to preheat air required for combustion will slightly improve thermal efficiency but the increase in steam output is less evident. Preheating of combustion air has in recent years only twice been applied in British practice; one example was Sir Nigel Gresley's high-pressure locomotive No. 10000. In this application the temperature of the air entering the ashpan was raised to about 250 deg. F.[24]

The second example was the Ljungström turbine locomotive, built by Beyer, Peacock and Company, which had a preheater in the smokebox feeding pre-heated air, via a sealed duct, to the ashpan. An earlier British example of preheating air was to be found on the Paget locomotive, but it would appear that in this case the temperature of the air could not have been raised much.

Other considerations apart, air preheating equipment occupies much space which in the modern locomotive is already at a premium. Thus, for example, W. J. Hammond's air-heating apparatus,[25] as fitted in 1908 on the L.B. and S.C.R. locomotive No. 189, was inapplicable to a large diameter boiler.

Many forms of boilers have been tried, of which only some are mentioned here. Of the others, some almost defy classification, e.g., the semi-water-tube firebox used by the Baltimore and Ohio Railway. The normal American firebox, with combustion chamber, had troughs longitudinally welded to the crown sheet. Water tubes ran from the water legs to the bottom of the troughs and additionally there were arch tubes.[26]

Generally, water-tube boilers were most inaccessible for repairs, strength as a beam was absent in a marked degree, and contraction and expansion stresses were difficult to avoid. A serious objection to a water-tube firebox from the driver's viewpoint was the immediate and very considerable fall in the water level recorded in the gauge glass when the regulator was closed while the engine was working hard. This was attributable to the relatively small amount of water carried in the upper drum, and was disconcerting, to say the least, to anyone unfamiliar with this characteristic.[27]

The Stephenson boiler had no difficulty in holding its own against all competitors for, as pointed out by Mr. A. W. Bruce, it had strength in all directions, was accessible for cleaning and repair, could be completely insulated, provided proper cross-sections for gas-passage velocities, and was reasonably efficient. No other type of boiler ever tried for locomotive use had all these attributes.

As Mr. O. V. S. Bulleid concluded in his presidential address to the Institution of Mechanical Engineers in 1946, the Stephenson boiler has its shortcomings but no one has produced anything better. Alternatives have often been tried which should, on paper, have been an improvement, but have more often than not turned out to be much worse. While the purpose of designers of unorthodox boilers was almost invariably to reduce fuel consumption, as Sir Nigel Gresley stated the cost of maintain-

ing and renewing boilers equalled the cost of the large quantity of coal burnt; generally speaking, however, designers continued to concentrate on the fuel aspect, rather than on ideas for reducing maintenance costs.

We are indebted to Mr. I. K. F. Pearson, who was responsible for the Sentinel locomotive trials, for the loan of the group photograph at the beginning of this article.

To be continued

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"BLACK TOP" ROADS

The Bituminous Roads Development Group has been formed, with an address at 76-78 Cecil Chambers, Strand, London, W.C.2, to promote the activities of its three constituent members: the Asphalt Roads Association, the Federation of Coated Macadam Industries, and the Road Bitumen Association. The group will act as a clearing house for all inquiries, passing them back to the appropriate member in order to take advantage of the experience possessed by the 200 firms that are represented. In particular, the group will collect and disseminate information, including the sponsoring of lectures, on all matters affecting bituminous road construction. Mr. H. W. Bawden has been appointed director of the group.

Letters to the Editor

COAL AS A RAW MATERIAL

SIR, It is disappointing to read in your description of the new Avenue carbonisation plant (ENGINEERING of November 2, page 546) that 1,400 tons of coke at 850 deg. C. are to be quenched by water every day, and the 1,760 million B.Th.U.s thus extracted dissipated by the four winds of heaven.

At the Dagenham plant of the Ford Motor Company, Limited, 650 tons of coke per day are dry-quenched by inert gases, which then pass through tube boilers and raise 650,000 lb. of steam at 180 lb. per sq. in. With plant of similar efficiency, the waste heat from coke quenching at the Avenue works could raise 1·4 million lb. of steam per day at the same pressure, which could be used for electric-power generation.

Have we such an abundance of fuel in this island that we can afford to continue wasting it on this scale? Can we only look to private enterprise to save fuel in the national interest?

Yours faithfully,

S. B. BAILEY.

London, S.W.1.
November 5, 1956.

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THE SHAPE OF THINGS

SIR, I have read the article "The Shape of Things," by Mr. R. Bentley Claughton, in your issue of October 19, 1956, page 482. Its stimulating conclusions prompt me to inquire whether Mr. Claughton could give us his views on the appearance of machine tools. Many firms now employ "stylists" to streamline their designs. Nevertheless, the natural evolution of designs and the increase in capacity of machines can produce some very satisfying results. Over the years we watched the beds of lathes get deeper and deeper and the legs get broader and shorter, until the day came when the lathe shape, as we understood it, had actually disappeared and we were looking at a solid block, although the mind still insisted on seeing the well remembered function in the newly styled form. The Germans are adept at this sort of evolution, especially as the aftermath of war enabled them to start afresh. I am sure, too, that Mr. Claughton could write a panegyric on locomotive shapes, particularly Gresley's Great Northern "Pacifics"; their appearance of mighty power under restraint has never been excelled.

Yours faithfully,

J. V. S. BROWN.

Visual Planning Systems, Ltd.,
Athlon-road,
Manor Farm Estate,
Alperton,
Middlesex.
November 5, 1956.

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POLITICS IN SWISS INDUSTRY

SIR, The Weekly Survey note under the above heading on page 518 of your issue of October 26, makes a regrettable exception to your usually well informed articles.

Ticking off material inaccuracies, one might start with the cuckoo clock, which calls from the Black Forest in Germany, and not from Switzerland; with the fact that Hovag never produced synthetic petrol, but alcohol from wood; that nobody wanted to buy Hovag; and so on.

The subsidy Hovag received for alcohol was pumped from the pockets of motorists into the plant, even after the necessity for stretching petrol supplies vanished after the war. This subsidy was granted for the production of a certain quantity of this alcohol, on the condition that measures be taken to convert the plant to the production of something else afterwards, and that Hovag become self-supporting. Ten years after the war no signs of conversion were seen and, in return for the countless millions received, Hovag did not even permit a glimpse into its books. The subsidiary companies flourished; where did the money come from? There were some doubts concerning its provenience from the sales of their products.

Compulsory admixture of the Hovag-juice brought along increased consumption of expensive petrol and engine troubles, but it must be admitted that it meant a thriving business for manufacturers of gaskets and paint, as these two were literally eaten away by the brew. Motorists would have preferred to pay for the alcohol and watch it go down the drain instead of having it mixed with their petrol.

By the way, the referendum means that 30,000 citizens can ask for a vote and as there are now about half-a-million road vehicles in Switzerland, those 30,000 signatures were not difficult to obtain. There was another issue at stake, too, namely whether it is to be permitted that a subsidised company living off the taxes, might enter into competition with private industry paying those taxes. Finally, the group of industrialists, who, according to your Survey, wanted to buy the Hovag, had no such intention. What they promised was to put up a wood-pulp factory in case the Hovag had to discharge labour.

The subsidy was repealed, everybody waited for the crash, and behold, nobody was discharged; Hovag simply had to be run like any other business! The last paragraph of your article is all too familiar to Swiss readers. These arguments are invariably brought up after each votation of this kind—by the losing party. I do not know where your writer got his information; a fitting punishment for this kind of journalism would be to force him to read all the articles that appeared on this subject in the Swiss Press. He would be a very busy man from now to Christmas.

And though the economic policy in question does not seem to please your writer, we are getting along not so badly with it, thank you.

Yours sincerely,

GEORGES FÖLDES.

Gemshalde 3,
Schaffhausen,
Switzerland.
November 3, 1956.

Editor's note: Mr. Földes has allowed his indignation with Hovag to get the better of him. Our note took the Hovag subsidy as an example of a complex industrial problem that had been the subject of a referendum. So far as cuckoo clocks are concerned, we can only plead that our ignorance is shared by many others, including Graham Greene and Orson Welles. Otherwise what Mr. Földes says bears out our contention that the referendum has limitations as an instrument of economic policy. The majority of Swiss industrialists would agree that there are other factors besides the use of the referendum to account for the success of Swiss economic policy.

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WATT STEAM ENGINE WANTED

SIR, We are anxious to locate a marine type, or similar, vertical steam engine by James Watt and Company. Particularly are we interested in acquiring an engine of reasonable size, made in the latter part of the Nineteenth Century.

If any of your readers know of an engine which would be relatively self-contained, we should be very pleased indeed to hear from them.

Yours faithfully,

N. W. BERTENSHAW,
Keeper.

City Museum and Art Gallery,
Department of Science and Industry,
Newhall-street,
Birmingham, 3.
November 9, 1956.

Weekly Survey

Cover Picture: *The teeming or pouring of molten steel from a suspended ladle into the moulds beneath it is a skilled operation. By the judicious handling of the stopper bar, the teemer regulates the rate of the flow of the liquid steel according to its temperature, composition, and other characteristics, thus ensuring that the moulds are filled effectively and sound and satisfactory castings obtained.*

* * *

Prospect of Oil Rationing

Estimates of the time required to clear the Suez Canal have ranged from one to three months, but it will probably be considerably longer before normal supplies of oil are resumed from the Middle East owing to the need to reassemble tankers which have been diverted to American ports or are operating round the Cape. The extent to which United Kingdom oil supplies are likely to be reduced cannot be accurately estimated since it depends on how far production in the United States and the Caribbean area can be stepped up to meet the deficiency.

In 1955 United Kingdom consumption of petroleum products (other than lubricants, bitumens and certain other miscellaneous products) totalled about 21½ million tons. It has been estimated that 50 per cent. of this was brought through Suez and a further 20 per cent. came across Syria through the Iraq Petroleum Company's pipe-line which has been severely damaged. If all tankers on Middle East routes were diverted round the Cape the reduction in supplies, once the initial dislocation had been overcome, might be of the order of 25 to 30 per cent., but this figure stands to be reduced to the extent that supplies can be obtained from the Western Hemisphere.

In imposing a 10 per cent. cut on deliveries by the oil companies to their customers, the Minister of Fuel and Power stated that this was a precautionary measure to avoid formal rationing and to permit a more detailed assessment of the position by the Oil Industry Emergency Committee. If further restrictions prove necessary it should be possible to lessen the impact on industrial users by reducing the amount of catalytic cracking so that the output of fuel oil and of gas and Diesel oil from U.K. refineries is increased by about 5 per cent. at the expense of motor spirit. The main consumption of fuel oil is by the steel industry (1·5 million tons in 1955) and for steam-raising including electricity generation (1·4 million tons); and of gas and Diesel oil, the principal consumption is by transport (1·6 million tons) and gas manufacture (0·5 million tons). Total industrial consumption of fuel oil in 1955 amounted to 4·9 million tons, and of gas and Diesel oil 1·7 million tons.

The Federation of British Industries have stated that, having regard to the level of stocks in this country, the 10 per cent. cut need have no untoward effect on production, but if continued for any length of time it could reduce steel production by about 750,000 tons per annum. It is therefore important that if reduced supplies are likely to persist, a formal rationing scheme should be introduced as early as possible in which full weight can be given to industrial priorities.

* * *

Railway Timetable

It is apparent from the Transport (Railway Finances) Bill which was published at the end of last week that timing is the critical factor in the Government's plan for advancing loans to British Railways, discussed in a note in these columns, page 550, November 2. The loans proposed under the Bill are to be of two kinds. For the first type the B.T.C. may receive special loans to meet revenue deficits incurred by the railways in any of the years 1956 to 1962; in arriving at the amount to be advanced, revenue surpluses from the remainder of the B.T.C.'s undertakings will be taken into account and the total of such loans will not exceed £250 million. The second type of loan will be made to cover interest on special loans. A time limit is to be imposed here as well. This second type of loan will be made only within a period up to five years after the end of the year in which a loan of the first kind was made. No loan can be made after 1964. While no formal limit has been set to this second type of loan it seems probable that, at current rates of interest, a maximum of £75 million or £80 million will have to be allowed for. The grand total thus comes to about £330 million.

Repayment of the loans is to begin not later than the seventh year after that to which the loan relates. After that, repayment is to be made as directed by the Minister of Transport so far as times and methods are concerned, subject to the approval of the Treasury. Power is given to the B.T.C. to meet interest on capital borrowed for British Railways during the years 1956 to 1965 by further borrowing. Interest can be met by borrowing, however, only for a period of three years after the end of the year in which the capital sum was borrowed.

It is clear from these provisions that British Railways will run into their critical period round about 1962. By that date the B.T.C. hopes to be at the break-even point, and the success of the whole idea depends on the B.T.C. being able to operate at a profit after that point has been reached. The gloomy side of the picture is that such estimates are liable to have a large margin of error; the bright side of it is that the Railways are now assured that nothing short of a national calamity will interfere with their top priority for modernisation.

* * *

Engines for Oil Fields

The announcement by Davey, Paxman and Company, Limited, that they are now offering a full range of portable power units to the oil industry in the form of standardised package sets reduced to essentials, draws attention once more to the success of the British oil equipment industry in recent years. In this particular case the sets have been operating in nearly 30 countries and it is claimed that they have competed successfully with American concerns. These Drilpaks, as they are called, are offered with capacities ranging from 100 to 1,000 s.h.p. The engines have been designed to facilitate transportation on lorries when mobility is required.

The sale of these units has required a world-wide service and spares organisation, as well as attention to packaging problems and local operating conditions. This indicates a determination to develop this market while the demand is expanding and there is no doubt that, in the comparatively near future, there is going to be a further large demand for portable power packs for oil fields. There are, however, two important considerations in this field which are likely to affect developments. The first of these is the future of different transmission systems. There is a growing tendency to use the torque converter in conjunction with over-centre clutches instead of a hydraulic coupling. This involves only problems of ancillary equipment so far as the Diesel engine manufacturer is concerned which has been met by Paxman's in a matched range of Brockhouse converters available as alternatives to fluid couplings. The second consideration is the possibility of increased competition for the Diesel itself. Some manufacturers of oil-field rigs are looking to the introduction in due course of the gas-turbine, using natural gas from the site as an engine fuel. These units have the attractions of robustness, local fuel supplies and a simplified transmission system. The large-scale development of the gas-turbine in this field may be some distance off, but the reciprocating gas engine is already available in the same power range as the Diesel. Somewhat nearer, however, is the possibility of a greater use of electric power at proven wells, increasing the competition from electric motors, especially as hydro-electric schemes develop, and this might make itself felt well within ten years.

* * *

Ironfounding

The output of iron castings in this country during the first six months of 1956 was 2,062,000 tons, compared with 2,005,000 in the first half of 1955, and it seems possible that the 1955 record output of 3,925,000 tons may be broken in 1956 and a new record established with an output of approximately 4,000,000 tons. It is emphasised, however, in the recently-issued annual report of the executive committee of the Joint Iron Council for the year ending June 30, 1956, from which the figures we have quoted are taken, that conditions in the industry have been disturbed during recent months and that the fortunes of various sections of the industry have differed widely largely as a result of the economic policy of the Government.

That the country generally is prosperous was stressed by Sir Edward Boyle, Bt., M.P., when, as Economic Secretary to the Treasury, he proposed the toast to the "Iron Industry" at the annual banquet of the Council, held in London, on November 6. He said that, of late, exports from Britain had risen substantially, both in volume and in value. Throughout the annual report of the Council emphasis was laid on the need for continued research, training and development. He welcomed the close connection between the Joint Iron Council and the British Cast Iron Research Association which had enabled that Association to extend its research activities over an ever widening field.

The value of research and the help given by the Council to the British Cast Iron Research Association was also alluded to by Mr. E. Carey-Hill in his response to the toast and it is of interest to read in the annual report that the Council is, moreover, supporting research by the British Iron and Steel Research Association, in connection with pig-iron production and has increased its grant for this purpose in the current year. Furthermore, the Council makes a grant to the Institute of British Foundrymen. This, it is stated, has been expended on staff and the meetings expenses of the various technical committees and on the printing of a report on internal stress in castings.

* * *

Industrial Development in Brazil

The announcement earlier this month that 17 representatives of the Japanese steel and other heavy industries have arrived in Brazil to study a project to build a steel mill in the State of Minas Geraes poses the question of whether British manufacturers are doing enough to take advantage of the improved political and economic situation in that country. Largely as a result of the limited multilateral payments system known as the Hague Club, British exports of machinery, including electrical equipment and railway vehicles, rose from £1·6 million in the first six months of 1955 to £4·1 million in the first half of 1956. On the other hand, exports of road vehicles and aircraft fell from £600,000 to £200,000.

It is, however, in the establishment of new industries in Brazil that this country appears to be falling behind some of her principal competitors, notably the United States, Germany and Japan. The United States has financed Brazilian development on a basis which naturally

encourages the purchase of United States plant and machinery, but which also releases funds and provides new opportunities for industrialists in other countries. German manufacturers in particular have announced important plans during the current year. Established German firms in Brazil, such as Telefunken and Siemens, are increasing their capital, while Krupps are to start manufacturing lorries, buses and tractors in co-operation with Lanz. They are also to undertake locomotive repair work and will later produce Diesel engines, including units for locomotives. Daimler-Benz are also to start the manufacture of Diesel engines, and Hartmann and Braun of Frankfurt are to produce precision instruments. In addition to their interest in the construction of the steel mill, the Japanese are planning to produce motor vehicles and textile machinery and to establish a shipbuilding industry. They are also reported to be considering hydro-electric power development.

While Babcock and Wilcox are investing about £1 million in a factory in Brazil and other British companies—including Platt Brothers, Metropolitan-Vickers, the Automatic Telephone and Electric Company, and Standard Motors—are also producing locally or are about to do so, some of these developments are on a relatively small scale. German manufacturers on the other hand appear to be planning their factories not only with an eye to the internal Brazilian market, but also to the possibilities of exporting to other South American countries.

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Soviet Electrification

Some interesting facts concerning the development of electricity supply in the U.S.S.R. were brought back by a British electricity supply delegation, who, under the leadership of Lord Citrine, spent three weeks as guests of Mr. Malenkov in the spring. A short account of the salient features of this development was given by Mr. J. Eccles, deputy chairman (operation) of the Central Electricity Authority and past President of the Institution of Electrical Engineers, at a meeting of the Institution last week.

The current five-year plan caters for an increase in installed electrical generating capacity from 37,000 MW (1955) to 75,000 MW (1960). Of this fantastic increase—which Mr. Eccles tells us has been planned down to the smallest component—64 per cent. will be provided by conventional thermal stations, 29 per cent. by hydro-electric stations and 7 per cent. (2,700 MW) by nuclear stations. Some indication of the extent of hydro-electric development is given on page 633, where we publish an account by members of a hydro-electric delegation which has also recently visited the Soviet Union. The largest sets in use are 150 MW capacity, operating at 2,400 lb. per sq. in. and 1,050 deg. F. with reheat at 977 deg. F. So far the Russians have not adopted the principle of "one boiler one turbine", even on reheat sets. Designs are ready for 200 MW sets and some members of the delegation visited a thermo-technical research institute where an experimental boiler was operating at 4,600 lb. per sq. in. and 1,100 deg. F.

The largest hydro-electric sets in operation are 105 MW (20 have been installed at Stalingrad power station on the Volga) but here again 200 MW sets have been designed and two stations each incorporating 18 such sets, operating at 250 r.p.m., have been planned. The problem of distributing hydro-electric power, in a country where distances are great and population thinly spread in the areas of the power stations, is being tackled by promoting local industrial growth including (according to the hydro-electric delegation) the creation of new towns, and by using very high voltage lines. A 400 kV double-circuit line links Kuibishev to Moscow (505 miles); the delegation were impressed to note that alternating current was being transmitted at so high a voltage. An experimental 200 kV direct-current line is in service near Moscow, and an 800 kV direct-current line is being constructed between Stalingrad and the Donetz basin (300 miles). If this is successful the Russians will standardise on 1,000 kV for their long distance direct-current transmission between Siberia and European Russia.

Other points of interest mentioned by Mr. Eccles were the tendency to build combined heat and power stations in the cities (already about 100 are in service) and the carrying out of extensive fabrication of boilers in open sites adjacent to the power station. The delegation were impressed by the " extensive and intensive " research going on, and by the fact that professors and teachers are paid higher salaries than are given for comparable posts in industry.

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Anti-Monopoly Law in Denmark

Last year the Danes passed a new law against monopolies and restrictive practices. The law has three objects: the abolition of unreasonable margins, the maintenance of free entrance to trade and industry, and the control of restrictive practices. The over-riding purpose of the legislation is the promotion of efficiency. In carrying out the provisions of the Act the emphasis is on control. Restrictive practices are not prohibited but brought under control. Resale price maintenance agreements, for example, are permitted provided they have been approved by the Monopolies Control Authority; two examples of approvals given so far are fertilisers and rubber footwear. As in Britain, books are subject to fixed resale prices, but reduced prices are enforced for schools and libraries. All agreements on exclusive trading, price leadership or other restrictions must be registered with the Monopolies Control Authority, and all registrations are published in the official Gazette. At the end of 1955 these totalled some 1,500.

The Monopolies Control Authority, which meets once a fortnight, consists of a chairman and 14 members, a majority of whom must be independent of business interests affected by the Act; the members are paid for their services. As in Britain, the universities are the main source of independent members, but the Danes have pressed the presidents of various women's organisations into service. An Appeal Tribunal has also been set up, to which any firm affected by a ruling of the Control Authority may go, but with the Act in operation for a year it has shown itself to be reasonably flexible. The obligation on the Control Authority to negotiate with all the parties concerned means that there is ample opportunity for special cases to be put forward; the fact that the Authority represents a variety of interests is taken to be a strong safeguard against partiality.

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A Changing Pattern in Motor Vehicles

The announcement by the British Motor Corporation and the Standard Motor Company of their 1955-56 results completes the picture begun by the Ford Motor Company this summer. B.M.C., like Ford and Rootes, say their turnover was maintained last year, but their profit was 35 per cent. lower, compared with the 50 per cent. decline reported by Ford during the first half of 1956 as against the same period in 1955, and with the 43 per cent. reported by Rootes. Standard has come off by far the worst: output of cars is down by over 9,000 to 79,360, and that of tractors by 18,000 to 52,869 (year ending August 31); net profit is reduced from £1·95 million to £393,000.

Both Standard and B.M.C. suffered heavily from short-time working and strikes, which must have affected profits. Moreover, extensive re-tooling has been carried out by both companies and expenditure on new machinery has been high. There is little doubt that the worst enemy of motor manufacturers is under-employment, of men or machines. They must now look to their expansion programmes, to meet the demand they have confidently plotted upwards. Vauxhall are going ahead with a large new factory. Ford have given no evidence of a change of heart since the announcement of their expansion plans. While they may well be right in the long term, artificial restrictions in the home and some export markets are likely to test their courage to the full. Competition will become even keener, and the smaller companies—who have been the main losers so far—will find it increasingly difficult to stay the pace.

Among suppliers to the motor industry reporting last week were several manufacturers of castings and forgings, including Ductile Steels Limited and Neepsend Steel and Tool Corporation Limited. Both were confident that demand for their products was rising. Sir Stuart C. Goodwin, chairman of Neepsend, said output had been well maintained during the past six months " despite the recession in the motor industry," and Mr. Frank A. Hall, chairman of Ductile Steels, expressed the belief that the recession among users of his company's light rolled products " is only of a temporary nature." In both cases falling demand from the motor industry had been absorbed by rising demand in others.

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Heat Exchangers, Inter Alia

The annual report of Serck Radiators Limited for the year ended August 4 shows that the company supply not only the motor industry—as suggested in these columns previously—but a wide variety of manufacturers requiring heat-transfer equipment. These include shipbuilders, makers of aircraft, sugar machinery, petroleum plant, oil engines, electrical machinery, locomotives and other heavy engineering products. The acquisition last year of the Audley Engineering Company, who specialise in the manufacture of valves for controlling the flow of liquid and gas in pipelines, has already proved valuable and has doubtless played an important part in offsetting the reduction of business from the motor industry. The chairman, Mr. W. H. Newton, comments that fluctuations in the prices of non-ferrous metals added further to the company's difficulties. Nevertheless—perhaps due to the inclusion of eight months trading by Audley—trading profits are some £38,000 higher, at £918,783, than the previous year. The current year started with a very full order book in most departments and should yield good results, despite rising costs and increasingly keen competition.

Another manufacturer of heat-exchange plant and of many other products, Brightside Engineering Holdings Limited, report greatly increased turnover and higher profits. Their chairman, Mr. Ambrose Firth, announces the completion of a decentralisation scheme begun over a year ago. The Brightside Foundry and Engineering Company, Limited, now operate the foundry and engineering divisions of the group as a subsidiary company. Good orders for rolling mill projects have been booked and a scheme for the reconstruction of the roll foundry and machine shops, embodying some additional capacity, is expected to be completed with the shops in production by the end of this year. The Heating and Air Treatment Company, also operating as a subsidiary, have a record order book and report continuing growth in industrial demand for up-to-date heating, ventilating and air conditioning plant. Buckley and Taylor, Limited, the subsidiary company who make heat exchangers, condensing and distilling plant, also report heavy orders.

Industry's seemingly insatiable demand for thermal engineering continues to grow, and is ahead of supply for most types of heat exchange plant (except perhaps car radiators, though even there the situation is changing). The prospects of companies such as Serck and Brightside, both prominent in the supply of their type of equipment to the heavy engineering industries, would appear to be very good indeed.

ORGANISING FOR RESEARCH

1—CHOOSING THE RIGHT PROJECT

By E. I. Brimelow, M.ENG.

The first of a short series of articles reviewing the recent conference on the "Direction of Research Establishments," held at the National Physical Laboratory, Teddington. The author is industrial and scientific liaison officer at the Laboratory.

As it is carried out to-day, whether in industry, government departments or the universities, research is a complex and expensive business. Gone are the days of Faraday and Davy, and those of their generation, when scientists were able to conduct their own individual researches from private funds. So costly, indeed, is modern scientific research that even the universities would be unable to undertake it were it not for the aid of substantial grants from the Government. For the financial year 1955-56, it has been estimated that about £325 million, or 2 per cent. of the country's gross national product, was spent on research and development in Britain; and that, for the year 1953, the equivalent of about £1,320 million (taking 2·8 dols. to the pound) was spent by American industry on similar work. Furthermore, there has been a steady increase in recent years in expenditure for these purposes; an increase which, at the present time, is rated at from 10 to 12 per cent. a year in the United States. It may be asked why such large-scale investment in scientific research is taking place. The answer is to be found in our modern industrial development: the electrical, radio, and chemical industries all had their foundations in the results of scientific research. Progress in electronics, aircraft and nuclear power, also, is very much dependent on basic and applied research. In a competitive industrial world, the wise direction of Britain's research effort and the efficient use of her available scientific manpower is vital to the well-being of the country, and may well be a major factor in determining her status in the community of nations.

Many of the factors associated with successful business management apply equally to the field of research management. These include personal factors, such as inspired leadership and the maintenance of good staff relations, which provide an environment for creativity and an enthusiasm for work. Then there are the related and no less important questions of remuneration and the provision of suitable incentives. Other aspects are problems associated with the selection of research projects, the stopping and starting of work, the assessment of its progress, and costs. There are, also, considerations arising from the necessity to provide adequate facilities in the form of buildings and equipment.

Resources and Strategy

Some current ideas on these phases of research organisation were considered at the symposium on "The Direction of Research Establishments," held at the National Physical Laboratory, Teddington, from September 26 to 28 last. The conference was attended by some 180 delegates, representing 17 different countries, and it is the purpose of these articles to review the papers and discussions then presented.

Considering the country's research resources in general, there are always, at any given time, more items available for research than there are research workers available for their investigation, and it becomes increasingly important that the best use should be made of such scientists and technologists as there are. This difficulty raises such questions as the best places for work to be undertaken and the type of work that should be done by any particular research organisation. Equally important is the problem of how to avoid the overlapping of work at the laboratories in the universities, large industrial organisations and government research establishments. The increasing complexity and specialisation of modern scientific research makes it virtually impossible for all the subsidiary aspects of a research project to be dealt with within one laboratory. In his paper, Professor J. D. Bernal,[1]* Birkbeck College, London, stressed the importance of referring work to the appropriate specialist organisations. He considered this to be the *raison d'être* of the research associations and of such national laboratories as the National Physical Laboratory. The universities, he felt, had generally been regarded as the place for fundamental or basic research, and it was also generally accepted that industry should not unduly influence the research work they undertook. In industry, on the other hand, the emphasis was on applied research. That both the universities and industry could benefit by including in their main programmes some selected work of the other type were views expressed by Professor Bernal and by Dr. C. G. Williams, of "Shell" Research Limited. The national laboratories, Professor Bernal said, played an important role in the field lying between the extremes of basic and applied research: a field designated as "background" research. In his opinion, this network of laboratories should provide a channel for a two-way flow of problems and ideas with the government laboratories, thereby providing a common meeting ground. In this regard, it was thought that there was a danger, in certain laboratories, of the staff becoming bogged down on relatively small pieces of research and of spending a disproportionate amount of time on them, to the neglect of more important projects. It was considered important, too, that those responsible for framing policy should weigh continually the needs of industry in regard to further research, when determining research programmes of the national laboratories. In this connection, it was suggested that it might not always be a question of stopping or finishing a particular piece of work, but of transferring it to a more appropriate organisation. Good liaison between the various laboratories could play an important part in ensuring a continuity of worthwhile projects.

Dr. Willis Jackson,[2] director of research and education, Metropolitan-Vickers Electrical Company, Limited, stressed the importance of the teaching function of the universities. Research at the highest possible level in a teaching department could be inspiring and stimulating to both the teachers and the taught. For this purpose, research need not be in fields of immediate interest and direct technological significance. Indeed, in his view, it was better that it should not be so. He maintained further that research had but one meaning—the intellectural activity of researching. The outlook, approach and method of the true research worker was the same, whether he was at a university or in industry, and Dr. Jackson gave examples to show that in large and progressive firms, with ample resources, the research work could be just as "long term" as much university research was, and that its leaders performed a teaching function towards their juniors analogous to that to be found at the universities.

Optimum Size of Organisation

In his opening address, Dr. G. B. B. M. Sutherland, director, National Physical Laboratory, remarked that many of the problems arising in the direction of a research organisation arose because of its size. The practice at the N.P.L. had been for divisions to break away from the parent organisation and to become separate establishments; for example, the Engineering Division had become the Mechanical Engineering Research Laboratory and the Radio Division had become the Radio Research Station. Two new divisions had been created in their place, namely, the Mathematics Division, and the Control Mechanisms and Electronics Division. He inquired whether this procedure was a pattern which might usefully be followed by many other institutions.

Comments on this problem of the maximum size of a research organisation were made indirectly by members in discussions at various sessions throughout the conference. Dr. A. V. Astin, National Bureau of Standards, Washington, thought there was no rigorous answer to the question, but he suggested, as a possible solution, that an establishment should be of the most suitable size to enable it to carry out the mission assigned to it. The general feeling was that a form of organisation and the devolving of responsibilities became necessary when the number of senior scientific staff exceeded about one hundred. With smaller groups, the work could be carried out on a personal basis with fairly free communicaions between individuals, so that all the members of the staff knew what each one was doing. When larger numbers of staff were involved, with the consequent spread of buildings, some of which might house large and expensive equipment, it became necessary to have more formal organisation and there was the need to follow set rules, as the best compromise between conflicting interests.

Mr. G. W. H. Gardner, director, the Royal Aircraft Establishment, thought the optimum size of an establishment depended on the scope of its work, that is, whether it was concerned with development work as well as research, and on the number of branches that it could usefully contain. Bright ideas were more likely to arise and be recognised as a result of the close integration of the work of a number of branches. In the case of a large organisation of this type, it was essential to delegate authority and to provide efficient channels of communication. The major difficulty was to prevent growth at an alarming rate; to do this it was not always necessary to cut down the work but rather to find outside support.

Selecting Research Work

The theme that all research work is chancy was developed by Professor Bernal when introducing his paper. In view of this, he said, he preferred to take the bigger risks and to concentrate on "long term" research that could potentially lead to innovations and new processes in industry, rather than on those researches where fewer risks were involved and which were meant to bring about small and gradual improvements in existing machines and processes. This outlook was perhaps to be expected of the fundamental research worker, the industrial significance of whose work might not become apparent for many years.

Dr. C. G. Williams, "Shell" Research Limited, perhaps expressed the feelings of many concerned with research in industrial laboratories when he said that there should be no belittling of the results of detailed improvement work, which had led to important developments in industry. Weight was given to this argument by Dr. Williams, when he pointed out that there were definite limits to the rate at which radical improvements could be introduced, on account of the large capital expenditure and major re-organisation of personnel which was involved.

Dr. Willis Jackson,[2] director of research and education, Metropolitan-Vickers Electrical Company, Limited, commented in his paper that there was always a certain amount of chance about those fields of research which proved later to be of considerable technological importance. He observed that the really interesting thing about this was that "chance" always seemed to fall to a man of outstanding ability and originality. For all practical purposes, the choice was then made by him, and, whatever the

* A list of the papers discussed at the conference and referred to in this account of the proceedings will be provided at the end of the concluding article.

environment, those in administrative authority wisely did all they could to assist him to pursue it. Otherwise, he was likely to change his environment, at a cost to the morale of the establishment concerned which might considerably exceed even the loss of his individual contribution. In industry, useful items of work resulted from discussions between engineering and research staffs. Dr. Jackson added, in the ensuing discussion, that he thought it was the responsibility of industry to extract useful items from the universities and the government laboratories, and he further suggested that, when work from these laboratories went into industry, the scientists responsible for its development should be encouraged to go with it.

Dr. Astin referred to the use now being made in the United States, especially by the aircraft industry there, of a basic research unit within a research establishment, for work on unprogrammed and uncommitted projects, namely, on problems selected by members of the staff themselves. One essential requirement, in such cases, was that the unit should be available to the rest of the staff for consultation purposes.

Assessment of Research

The difficulty in assessing the value of research and development work is that one is not dealing with tangible commodities, but with new knowledge, new ideas and new technologies, the immediate value of which it is not always possible to determine, although, at some future date, this value may be very large indeed.

Mr. A. H. Wilson,[3] managing director of research and development, Courtaulds Limited, gave three reasons in his paper for wishing to assess the work of an industrial laboratory. First, to determine from a scientific point of view, how efficiently, or otherwise, the research had been carried out; secondly, to draw up an economic balance sheet showing the relation between research expenditure and the profits derived therefrom; and thirdly, to decide which projects should be dropped and which should be continued. In presenting his paper, he said that he did not consider an economic assessment to be essential; nevertheless, it was important to ascertain to what extent the results from the laboratory were applied. He emphasised the need for an early and continuous assessment as the work proceeded, and that such an assessment should look to the future, bearing in mind such considerations as the chance of implementation on a commercial scale, the capital costs involved in the new plant required, and the profitability of the operation in the light of market surveys. Such an assessment, although primarily the responsibility of the research director, involved the co-operation of the research workers themselves and of the managers of other departments, such as the officials responsible for production, design and sales. Regarding the termination of a project, Mr. Wilson thought that the research workers concerned should help in the assessment and be ready to accept its consequences. Staff should be persuaded to drop projects, in order to work on problems which they accepted as being of greater urgency, and it was, he thought, better that the impetus for this course should come from those actually engaged on the work, rather than that it should be imposed from above.

Dr. Astin, in opening the discussion, felt that the question of assessment was of great importance. He recalled a paper given two years ago by Dr. Raymond Ewell, of the National Science Foundation, in which the economic aspects of research were emphasised and for which Dr. Ewell quoted a figure of 100 per cent. dividend to be expected, rather than the usual 6 per cent. from ordinary investment. A strong correlation was given between the growth of an industry and the money spent by it on research. Both he, and Dr. H. M. Stanley, Distillers Company, Limited, felt it inadvisable to make an assessment at too early a stage. In judging the results of a project, the forming of too hurried a decision must be avoided, and assessments by outside groups or committees not in direct contact with the work could lead to wrong decisions.

ELECTRIC POWER ORGANISATIONS IN EUROPE

The Committee on Electric Power of the United Nations Economic Commission for Europe (ECE) recently directed its secretariat to prepare a report* on the way electric power services were organised on that Continent. The resulting document covers such matters as the organisation of government services, of private and nationalised undertakings and the association of such undertakings. Information on bodies conducting research and publicity and on international organisations dealing with electric power is also provided. Nineteen countries are covered including the U.S.S.R., but no others behind the iron curtain, although Czechoslovakia and the Eastern Zone of Germany are partial exceptions. The report is valuable and will no doubt be studied with interest but it would have been improved, as its compilers admit, by greater uniformity in presentation. It would appear that no clear indication of what was required was sent out to the various authorities concerned, the results being that the replies vary in clarity, length and relevancy. It is to be hoped this will be changed when a second edition is prepared.

The first part of the report is devoted to an account of international organisations which are concerned with electric power supply, such as the World Power Conference and the International Electrotechnical Commission. It is purely factual and requires no further comment. The second and much longer portion deals with the organisation of electric power services in the different countries and is supplemented by data of production in tabular form.

GOVERNMENTAL ROLE

An interesting point which is brought out, is the part played by governments in electricity supply. This varies from country to country and is most apparent in the United Kingdom and in Ireland where, as is well known, almost complete "nationalisation" has taken place. In France the Ministry of Industry and Trade is empowered to deal with all matters relating to the production, transmission and distribution of electricity, but the Ministry of Agriculture is also concerned with distribution and with the use of water for hydro-electric purposes. Stations with an average production of less than 12 million kilowatt-hours per annum and with a capacity of less than 8,000 kVA are exempt from control as are also the state railways and mines, the Compagnie Nationale du Rhone and certain municipally controlled distribution undertakings.

In Italy, the Minister of Public Works is, broadly speaking, responsible for hydro-electric, development, all water courses being public property. On the other hand, thermal plants, including those using natural steam or gas, are also partly the concern of the Ministry of Industry and Commerce. Transmission and distribution lines operating at more than 5 kV must be authorised by the Minister of Public Works and those at lower voltages by the Prefect of the Province. The generation, transmission and distribution of electricity is in the hands of "bulk-supply" companies, municipal authorities and apparently also of private industrial concerns who sell their surpluses.

Government control of electricity supply in Sweden is not lacking in complications. Briefly, at organisational level major questions relating to hydro-electric development, whether by the state or private enterprise, are dealt with by "water courts." The construction of thermal stations is, however, mainly uncontrolled, although concessions for the erection of high tension lines must be obtained from the Ministry of Trade. The Ministry of Transport and Communications is also concerned with lines working at more than 40 kV and with the operation of state-owned waterfalls. Rural lines come under the Ministry of Agriculture. Generation and distribution are carried out by state, municipal and private undertakings.

The Union of Soviet Socialist Republics, Eastern Germany and Luxembourg are three other countries where the supply of electricity is largely under Government control. In the first of these, several ministries are concerned who deal with construction, generation and rural electrification. Detailed information is, as might be expected, meagre. In Eastern Germany there are 14 nationalised undertakings which supply in the main towns, although the interconnections between them are controlled by three other authorities. General control is exercised by the Central Electricity Administration of the Ministry of Heavy Industry. In Luxembourg there is a State Electricity Department, which is advised by a Supreme Electricity Council.

MUNICIPAL AND PRIVATE ENTERPRISE

Although governmental control under the Ministry of Works exists in Turkey, especially as regards future development, there are over 300 undertakings which are operated by municipalities, and a number of companies have also been established to construct large stations. In some cases surplus power is obtained from manufacturing undertakings and distributed by local authorities.

In Austria the Ministry of Transport and Nationalised Undertakings exercises a general supervision over electricity supply, but generation is in the hands of a number of companies which are either owned by local authorities or private enterprise. In addition, there is an "Interconnections Company".

The electricity supply industry in Western Germany is still being mainly operated on the lines existing before the war. Control is in the hands of the Ministry of Economic Affairs and by corresponding authorities in the Länder. Generation, transmission and distribution are the responsibility of seven large companies.

In Greece electricity supply is still undergoing considerable re-organisation and development under the supervision of the Ministry of Industry, and a Public Power Corporation has been given the responsibility of transmitting and distributing power subject to existing concessions.

While in Czechoslovakia all generating plant and transmission systems are nationalised, including those belonging to, for instance, the chemical industry, in Holland the State is not directly concerned with electricity supply, although it approves tariffs and has promulgated safety regulations. On the other hand, generation and public distribution has to be licensed by local authorities. Still less Governmental control is exercised in Belgium, where the producers of electric power, including the State and local authorities, are free to erect stations. A Permanent Electricity Board acts in an advisory capacity to the Ministry of Economic Affairs.

Electricity supply in Denmark is supervised by the Ministry of Public Works, which approves the construction both of power stations and high-tension transmission lines. It does not, however, operate or finance any system, nor intervene in price policies. In Finland, too, electricity supply is largely in private hands, although the local authority must approve the erection of transmission lines in towns. Power stations are, however, inspected by a Department of the Ministry of Trade and Industry. The latter body also promulgates safety regulations.

In Norway power stations and their related transmission systems are in either State, municipal or private hands. Production and distribution are controlled by the Ministry of Industry through a Hydro and Electricity Board which is, however, mainly concerned with water power.

* "Organisation of Electric Power Services in Europe" E.C.E. Report, H.M.S.O. (3*s*.)

METALLIC TRANSFER IN ENGINEERING OPERATIONS

RADIOACTIVE METHODS USED AT CAMBRIDGE

By Dr. F. P. Bowden, C.B.E., F.R.S.*, *and Dr. J. B. P. Williamson*†

Controlled experiments have shown that it is almost impossible to touch two surfaces together without causing some exchange of metal between them. This transfer is increased when no lubricant is present, or when slip occurs, or when great force is applied. In general the harder metal receives more contamination than the softer; but, even when the difference in hardness is as much as twenty times, some fragments of the hard metal can become adherent to the softer surface. These experiments have shown that in many engineering processes about ten to a hundred micrograms of the metal of the tool become permanently embedded in the surface of the product each time it is handled. The significance of this contamination of the surface is discussed. It is pointed out that the effect is not limited to the transferred fragment alone: under certain conditions it may initiate a continuing corrosion of the bulk metal to which it is attached and may influence its fatigue properties. Metallic transfer in many modern engineering operations is sufficiently large to merit attention.

In modern engineering practice great care is taken to provide metallic components with surface finishes which will satisfactorily withstand any adverse conditions to which they may be subjected. It is well known that the behaviour of a metal in any particular environment is largely determined by the nature of its surface. For example, the deformation and damage of the surface layers which can occur during mechanical manipulation can seriously impair the subsequent performance. In many engineering operations metal is handled with tools which are not of the same composition as itself. This article discusses the influence of the metallic transfer which occurs between the tool and the product. It will be shown that under certain circumstances this can become very considerable; it may exert an important influence on the behaviour of the metal, in particular on its corrosion and fatigue.

Whenever two metals are brought together contact first occurs at the points where the tips of the asperities on one meet the surface of the other. Initially the force driving the metals together is transmitted through these small areas of contact only, and consequently the local pressure is very great; so great in fact that it exceeds the yield pressure of the metals and causes them to deform plastically. The region of contact grows as the two surfaces deform to accommodate each other until it reaches such a size that the mean pressure over the area of contact no longer exceeds the yield pressure of the metal. The actual area of the contact may be as little as one millionth of the apparent area. However, over this small region of contact the metals are very strongly welded together. The local deformation of the metal which occurs near the areas of contact makes these regions stronger than the bulk of the solid; consequently when the metals are separated they often part not at the original interface but slightly to one side of it, in the region which has not been work-hardened. Small fragments of one are left behind on the surface of the other, and remain adhering firmly to it. It is almost impossible to touch two metals together without causing some contamination of this kind. Fig. 1 shows typical fragments of transferred metal. The transfer can occur from a soft metal to a hard one as well as conversely. The amount transferred is greatly increased if any slip occurs between the metals and also depends markedly on the presence or absence of lubricating and other films on the surfaces. A general account of the nature of the contact between metal surfaces has been given by Bowden and Tabor (1950).[1]

Some transfer may be expected to occur whenever a metal is handled with tools, and it is very probable that the final product will have small fragments of the metal of the tools used to shape and finish it embedded permanently in its surface. These tiny foreign particles may be undesirable merely as impurities. But the effect is not necessarily restricted to the transferred fragments alone: in certain environments they can initiate a continuing corrosion of the bulk metal to which they are attached.

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Fig. 2 Autoradiograph showing metal transferred from a hammer during a single blow on a flat copper surface. Transferred metal fragments show as white spots.

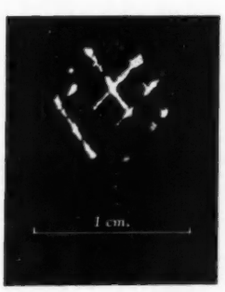

Fig. 3 Autoradiograph showing metal transferred during a single hammer blow on a nail head. The transfer is concentrated on the summits of the ridges on the nail head.

Fig. 1 Photomicrograph of a taper section of a steel surface after a piece of copper had been slid over it. Fragments of copper (dark) are seen adhering to the steel. Even small deposits of a transferred metal may affect the properties of the receiving metal, especially in respect of corrosion and fatigue characteristics. (Dr. A. J. W. Moore.) (Magnification: horizontal ×2,000, vertical ×20,000.)

EXPERIMENTAL DETAILS

Experiments have been carried out to investigate the amount and distribution of the metallic transfer which occurs when metals are manipulated. Several common engineering procedures have been studied under controlled conditions. Radioactive-tracer technique has been found to be a very powerful method of detecting and measuring the small transferred fragments. For each operation investigated the part of the tool coming into contact with the metal was previously made radioactive by neutron irradiation. Except where otherwise stated all the tools used in these experiments were made of normal tool-steel and, for the present purpose, only the activity acquired by the tungsten in them was significant. The radioactive fragments left on the surface of the metal were measured using either a Geiger counter or a scintillation counter. Only gamma rays were counted. Thus self-shielding was negligible and the entire amount of metallic transfer was measured. The specific activity of the tool under investigation was determined by counting the emission from a known mass of it, and hence the amount of transferred metal could be calculated.

Often it is important to know not only the amount of transfer but also its distribution over the surface of the product. This may be investigated by allowing the radioactive particles to record themselves by their own radiation from a sheet of sensitive film placed against the contaminated surface. The autoradiograph is then developed and printed as a normal photographic negative (Gregory, 1946).[2]

Transfer from Hammers.—One of the simplest mechanical tools is the hammer, and the action of striking one metal against another is very common in engineering practice. Experiments carried out with a radioactive hammer showed that metallic transfer was detectable after only a single blow. The amount was greatly increased if a glancing blow were struck so that some slip occurred between the contacting surfaces. Table I gives the quantities of adherent foreign metal measured. It should be noted that the transfer does not occur only from the softer metal to the harder (although, of course, it is predominantly in that direction). Small particles of the hammer, which had a diamond pyramid hardness of about 850 kg. per sq. m., were plucked out and embedded in the surface of much softer metal: the aluminium block, for example, had a hardness of only 38 kg. per sq. mm.

TABLE I. — *Metallic Transfer from Hammers and from Vice Jaws*

Metal studied	Metal struck with hammer. Transfer per blow	Metal gripped in vice. Total transfer from both jaws	Metal gripped in vice and struck. Transfer from jaws per blow
Aluminium ..	1·6μ gm.	0·6μ gm.	8·2μ gm.
Brass ..	0·7μ gm.	0·5μ gm.	5·8μ gm.
Copper ..	1·7μ gm.	0·9μ gm.	10·4μ gm.
Mild steel ..	0·9μ gm.	0·4μ gm.	5·6μ gm.

The hammer head and the vice jaws were of tool steel and had hardnesses of about 850 kg. per sq. mm.
The hardnesses of the blocks were: aluminium 38; brass 140; copper 105; mild steel 177 kg. per sq. mm.

Fig. 2 is an autoradiograph of a block of copper that has been hit once with a radioactive hammer. The gamma radiation from the radioactive fragments has blackened the negative at a number of isolated points leaving the inter-

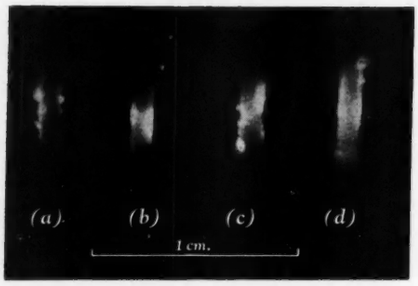

Fig. 4 Autoradiograph of metal transferred to Vitallium screws when the screwdriver was allowed to slip by different amounts. The amount of slip permitted increases from (a) to (d); this is accompanied by an increase of metallic transfer.

mediate areas unaffected. This illustrates very clearly that the transfer occurs randomly as small discrete particles, and not as a uniform layer. There are some places however where the transfer appears to be concentrated along straight lines. These are probably the crests of ridges caused by previous scratches in the metal surface. This point is clearly illustrated in Fig. 3, which shows the head of a nail hit by the same hammer. The figure indicates how the blow has been taken on the crests of the ridges which had been formed on the head of the nail during its manufacture.

Transfer from Clamps.—Frequently a metal is clamped in a vice in order that it may be manipulated with other tools. This can, itself, cause considerable contamination of the metal surface. Sheets of aluminium, brass, copper, and mild steel were gripped tightly in a vice between radioactive jaws and the amount of metal transferred to them was measured. The results are shown in Table I. Every time a block of metal is clamped in this way about half a microgram of the jaws becomes embedded in its suface. If a metal is struck while it is held in a vice the transfer is greatly increased. The blow causes it to slip slightly across the faces of the jaws, and although this movement may be barely perceptible it can increase the amount of embedded metal as much as tenfold (see Table I).

Transfer from Screwdrivers and Spanners.—The dependence of the amount of transfer on the degree of slip which is permitted is illustrated by a series of experiments in which contamination by screwdrivers and spanners was studied. These were carried out with instruments manufactured for use in orthopaedic surgery. A steel driver was used to insert a series of screws. Fig. 4 is an autoradiograph of the heads of four typical screws; it shows that the amount of adherent foreign metal depends markedly on how much the driver is allowed to slip in the slot. Table II gives the transfer observed in typical cases for both screwing and bolting. The influence of

TABLE II.—*Metallic Transfer from Screwdrivers and Box Spanners*

Transfer from steel screwdriver	To steel screws	To Vitallium screws
No detectable slip	17 μgm.	0·6 μgm.(*a*)*
Slight slip	22 μgm.	0·8 μgm.(*b*)
Some slip	45 μgm.	1·0 μgm.(*c*)
Much slip	65 μgm.	1·7 μgm.(*d*)
		* See Fig. 4

Transfer from steel box spanner	To steel bolts	To Vitallium bolts
Spanner applied once only, no detectable slip; great force used	38 μgm.	3·6 μgm.
Spanner applied twice, some slip; normal force used	43 μgm.	6·4 μgm.
Spanner applied six times, much slip; very great force used	103 μgm.	20 μgm.

The screwdriver had a hardness of 150 kg. per sq. mm. The box spanner used for the steel bolts had a hardness of 210 kg. per sq. mm.; that used for the Vitallium bolts had a hardness of 460 kg. per sq. mm.
All the screws and bolts had hardnesses in the range 300 to 400 kg. per sq. mm.

slip is clear. The Table also compares the transfer to steel with that to Vitallium (an alloy of cobalt and chromium). The results illustrate the fact that the transfer between like metals is much greater than that between unlike metals. Contamination in bolting is, in general, greater than that in screwing, probably owing to the greater force used and the more pronounced occurrence of slip. It can be as high as 0·1 mg. per bolt. A box spanner grips a bolt as shown in Fig. 5 and thus the regions of greatest pressure and slip are localised at the leading edge of each face. An autoradiograph of one of the six rectangular faces of the first stainless steel bolt quoted in Table II is given in Fig. 6.; this illustrates how the foreign metal is concentrated at the leading edge of the face. Fig. 7 shows that when much slip occurs between the spanner and the bolt contamination is more evenly distributed.

Transfer from Tool-Bits.—Several common procedures in engineering are normally carried out in the presence of a lubricant. Under these conditions the amount of transfer would be expected to be very much less, as direct metal-to-metal contact is prevented to a great extent by the presence of the oil (Rabinowicz and Tabor, 1951).[3] Two such operations are turning and drilling. In order to measure the amount of metal transferred from a tool bit during turning, rods, 2 in. in diameter, of each of the metals listed in Table III were mounted in a lathe and the end face of each was prepared using a non-active tool-bit. A 0·002 in. cut was then machined from each with a radioactive bit. For each metal the normal workshop procedure regarding the lubricant used and the speed of turning was followed. Transfer to the turned metal was extremely small in all cases investigated, and was not detectable on aluminium or brass. The ratio of the mass of the tool which became adherent to the turned surface to that which was carried away on the chips depended on the metal being cut; with copper, two-thirds of the mass worn off the tool bit was carried away on the chips, while with mild steel only 7 per cent. remained embedded in the surface. This observation is in close agreement with the data given by Merchant and Krabacher (1951)[4] (see also Colding and Erwall, 1954).[5] Table III gives the

TABLE III.—*Metallic Transfer from Tool-Bits and from Twist Drills*

Nature of metal studied	Transfer per sq. in. of turned surface	Transfer to $\frac{1}{4}$ in. metal sheet when a $\frac{7}{16}$ in. hole was drilled through it
Aluminium	None detected	0·4 μgm.
Brass	None detected	0·1 μgm.
Copper	0·7 μgm.	1·1 μgm.
Mild steel	0·18 μgm.	0·5 μgm.

The tool-bit had a hardness of 960 kg. per sq. mm., and the twist-drill a hardness of 860 kg. per sq. mm.

results and also those of an investigation of the transfer occurring when metals are drilled. In drilling, the distribution of the wear between the surface of the hole and the chips was similar to that when the metal was turned in a lathe.

Fig. 8 is an autoradiograph of the end of a copper rod which had been machined with a radioactive tool bit. There was barely enough radiation to affect the emulsion (this photograph was exposed for 200 hours). Nevertheless it is clear that some transfer did occur. Practically all the foreign metal that is there is distributed in a few discrete arcs.

Transfer from Twist Drills.—In general the amount of transfer from a well-lubricated twist drill is very small (see Table III), but under certain conditions relatively large quantities, of the order of milligrams, may be transferred (Bowden, Williamson and Laing, 1955).[6] If a twist drill is inserted obliquely through a hole in a sheet of hard metal in order to drill into some solid behind the sheet, then the thin edges on the shank of the drill may easily come into contact with the sides of the hole in the hard sheet and considerable friction may occur. Under these conditions the mass of the tool becoming embedded in the surface of the metal sheet can rise to several milligrams. This particular configuration frequently occurs in orthopaedic surgery, where pilot holes are often drilled into a broken bone to receive the screws which attach an internal splint; in this instance the resulting transfer may be very important.

Transfer from Riveters.—It has been shown that the transfer between metals is increased if there is any slip between the surfaces, and also if great forces are applied between them. In many methods of mechanical manipulation these two conditions apply to an extreme degree. Riveting is a good example. The results of some experiments in which a series of $\frac{1}{8}$ in. diameter rivets were pressed home using a riveter with radioactive anvils are given in Table IV. The values quoted are the total mass of the metal of the anvil transferred to both ends of each rivet, and

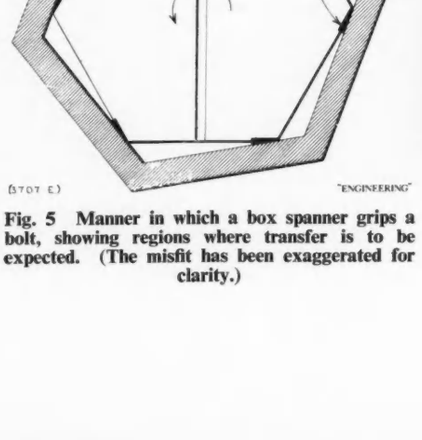

Fig. 5 Manner in which a box spanner grips a bolt, showing regions where transfer is to be expected. (The misfit has been exaggerated for clarity.)

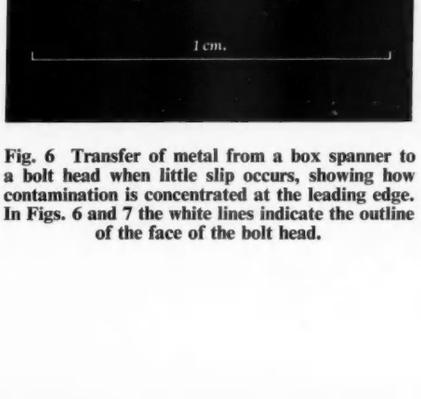

Fig. 6 Transfer of metal from a box spanner to a bolt head when little slip occurs, showing how contamination is concentrated at the leading edge. In Figs. 6 and 7 the white lines indicate the outline of the face of the bolt head.

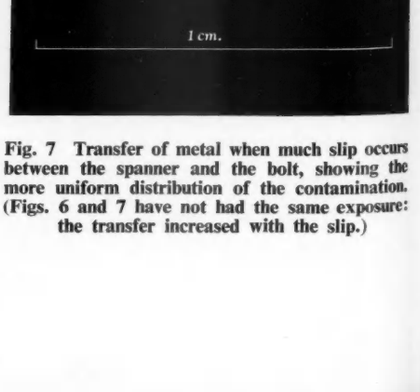

Fig. 7 Transfer of metal when much slip occurs between the spanner and the bolt, showing the more uniform distribution of the contamination. (Figs. 6 and 7 have not had the same exposure: the transfer increased with the slip.)

TABLE IV.—*Metallic Transfer from Riveters*

Nature of rivets	Total transfer to both ends of rivet
Aluminium	19 μgm.
Brass	40 μgm.
Copper	115 μgm.
Soft iron	53 μgm.

The riveter-head was of tool steel and had a hardness of 880 kg. per sq. mm. The hardnesses of the rivets were: aluminium 50; brass 160; copper 150; and soft iron 180 kg. per sq. mm.

are averages for twelve rivets of each metal. More than a 100 μgrams of foreign metal can be adherent to a rivet. Other mechanical manipulations involving gross plastic deformation of the metal will also result in considerable contamination. In particular, processss such as drawing and rolling may be expected to cause large amounts of transfer.

SIGNIFICANCE OF METALLIC TRANSFER

It is clear from these experiments that in many common engineering operations considerable quantities of metal are transferred from the tools to the product. The amounts are sufficiently large to merit careful consideration. For example, as the technique of refining metals becomes more and more advanced the transferred fragments resulting from contact with other solids can contribute appreciably to the total impurity content. This contamination will, of course, be merely superficial, although if the metal is subsequently annealed at a high temperature the foreign atoms will diffuse into it. In some cases the costly processes necessary to produce spectroscopically pure metal will be largely vitiated if the pure billet is subsequently manipulated with metal tools and allowed to become contaminated with transferred metals. If the specimen of pure metal is small, for example a fine wire, the contaminating metal adherent to its surface may form an appreciable fraction of the total mass. This problem is of particular importance in the production of zone-refined metals. Even when the composition of the metal is not rigidly specified, it is occasionally necessary to make extremely accurate analyses of small samples of it. The reliability of the result may be seriously impaired if particles of transferred metal are included in the sample.

The phenomenon of metallic transfer may be particularly important if the adherent fragment is of a metal which possesss some particular property very much more strongly than the solid to which it is attached. Its presence may then contribute appreciably to the response of the entire solid to certain stimulants. For example, small particules of ferromagnetic iron transferred from tools to the coil frame of a sensitive galvanometer could cause considerable changes in its sensitivity.

Transferred fragments can even be undesirable merely because of the space which they occupy. In the design of highly sensitive electric relays it is usual to construct the two contacting surfaces of noble metal in order to eliminate the insulating effect of a surface oxide (Chaston 1941)[7] (Wilson 1955).[8] However during the fabrication of the relay the oxide-free surfaces are manipulated with base metal tools, and particles from them become transferred. If when the relay closes the point of contact happens to be on one of these particles, the base metal will prevent the noble-metal surfaces from touching; the contact will then be entirely on oxide and the electrical resistance of the relay will remain high (Williamson, 1955).[9]

The significance of metallic transfer is not limited to the properties of the foreign fragment itself. Under certain conditions the particle can initiate a reaction which will continue indefinitely. In the construction of storage vessels for chemicals it may be important to consider whether any transferred contaminant on their surfaces could act as catalyst and cause the chemical to deteriorate. If the contaminated surface is in contact with an electrolyte, the foreign metal can provide the second electrode and create an electric cell; this may lead to the bulk corrosion of the metal in which the fragment is embedded. There is evidence that the transferred particles penetrate the oxide layer and adhere to the underlying metal. Since the resistance to corrosion of a passive metal is due to the protection of its superficial oxide layer, the dissolution of these embedded foreign fragments, if they are anodic, may lead to a serious breakdown of the protective covering and to the onset of continuing corrosion (Evans, 1946).[10] If the adherent particles are cathodic, continuing corrosion may again result. This phenomenon may merit careful attention in applications where metals are required to retain their passivity for long periods without attention. In particular, it may be important when stainless-steel orthopaedic appliances are buried in the human body (Bowden, Williamson and Laing, 1955).[11] If a metal component which has been contaminated with metallic transfer is subjected to permanent or transient stresses, local corrosion cracks may cause harmful stress-concentrations. Under these conditions the transfer may influence the fatigue of the component.

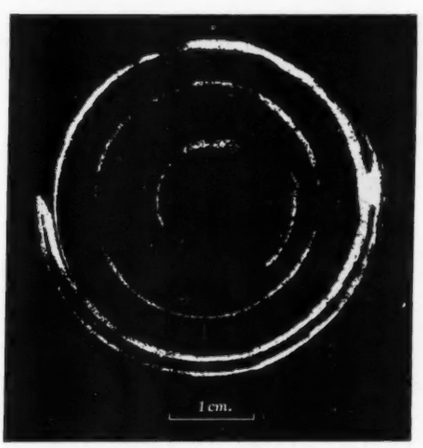

Fig. 8. Autoradiograph of the end of a copper rod machined by a radioactive tool. It will be seen that the metal from the tool is distributed in a few discrete arcs. The work was lubricated during machining.

In certain cases this form of corrosion may result in serious weakening of the mechanical strength of a structure which has been built of passive metal but assembled with base-metal tools. The large amounts of transfer which occur during the operation of riveting suggest that if the rivet heads are subsequently exposed to an electrolyte, undesirable corrosion and weakening may occur.

The effects of surface contamination resulting from metallic transfer may also be important in the fundamental study of the corrosion and passivity of metals. Small anodic or cathodic particles which have become adherent to the surface of a specimen could exert a marked influence on its behaviour under test.

REDUCING METALLIC TRANSFER

Undesirable transfer may be reduced in several ways. One of the simplest is, of course, by lubrication. The lubricant becomes trapped between the approaching surfaces and bears some of the load; this reduces the area of actual metal-to-metal contact and thus decreases the amount of transfer. A lubricant is effective in reducing contamination whether the contact between the metals is sliding, static, or impacting (Rabinowicz and Tabor, 1951)[3] (Rabinowicz, 1952)[12]; Transfer may be greatly decreased by avoiding, as far as possible, any slip between the surfaces. These two general principles are clearly illustrated by the amounts observed during the various forms of manipulation which have been investigated. In normal circumstances fragments are plucked out from each metal and become adherent to the surface of the other; but by controlling the relative hardness of the contacting surfaces the contamination can be made to go predominantly in one direction. Experiments have shown that the transfer from a screwdriver of hardness 150 kg. per sq. mm. to screws of hardness 380 kg. per sq. mm. can be reduced by a factor of ten by increasing the hardness of the driver until it equals that of the screws.

In many circumstances it is essential to manipulate metals in such a manner that transfer is unavoidable. It may then be necessary to remove the foreign particles from the final product by, for example, some suitable electrolytic treatment.

CONCLUSION

These experiments have demonstrated that whenever a metal is manipulated mechanically, small fragments of the tools used become torn out and embedded permanently in its surface. The amount of contamination is in general small: the results indicate that in many common machining processes the final product probably has between 10 μgrams and one milligram of foreign metal distributed over its surface. In some special cases, for example, in certain forms of drilling, the transfer can be many milligrams. Consequently the nature and constitution of the surface of the product depend not only on the original state of the metal from which it is made, but also on the methods and tools used to fabricate it. This form of contamination can have a profound effect on the subsequent behaviour of the metal. The results suggest that, under conditions where the surface properties are important, some attention should be paid to the composition of the tools and to the manner in which they are handled.

We thank the Royal Society for a grant to the Research Laboratory; and Tube Investments Limited, for a Research Fellowship to Dr. J. B. P. Williamson.

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MICROMETER HEIGHT GAUGE

A height gauge with micrometer action and a range of 12 in. has been produced by All Precision Engineering, Limited, Horsham, Sussex, and was shown at the recent Engineering Industries Association exhibition (London region). It is designed to replace the vernier gauge normally used on the marking-off plate and is both more accurate and easier to read. Known as the Microball, it consists of a micrometer head with a horizontal arm which slides on a hollow vertical column mounted on a base. Within the column are steel balls of known diameter, against which a plunger on the head bears, thus locating the latter at exact intervals along the height of the column. In the English graduated version, the balls are 0·500 in. in diameter and so the head is located every half-inch. Intermediate readings are obtained from the micrometer thimble and are within 0·0005 in.

THE SIZE AND SPEED OF SHIPS

We give below an abridged version of the paper on "Ships," presented by Mr. K. S. M. Davidson, of the Stevens Institute of Technology, Hoboken, New Jersey, U.S.A., at the recent International Congress of Applied Mechanics. A report of the Congress follows this article.

The capability of any vehicle for transport depends upon its "transport momentum"—product of speed and mass; taking speed V in knots and mass, or displacement, Δ in tons, the "transport momentum" for ships rose from about 150 to 15,000 between 14 and 1850 A.D., and from 15,000 to 1,500,000 between 1850 and 1950, the large increase of the last century being made possible by changing from timber to steel and from sail to power. The speeds and displacements did not increase independently of one another, but were related in a fairly definite way; thus for a period of about 1,000 years the product $\frac{V}{\Delta^{\frac{1}{6}}}$ for sailing ships was equal to about $1\frac{3}{4}$, this being due presumably to the limitations on speed imposed by the Froude number. As the size increased the stresses within the structure increased, because of the "square-cube law"—the fact that the cross-sections of a structure increase as the square of its size whereas the weight increases as the cube. The law places a limit on size for any particular material and design, and would probably have prevented wooden sailing ships from exceeding the sizes of the Clippers of the 1850's. It applies to dynamic as well as to static forces if speeds are increased so as to keep the Froude number constant.

The limitations of the square-cube law affect all types of vehicle, including living creatures. Nature appears to have reached her limit in the blue whale, which displaces about 150 tons, and this is the figure which the transport aircraft has just reached. Wooden ships reached 4,000 tons, and steel ships of 100,000 tons are now contemplated.

An increase in transport momentum from speed alone, by raising the Froude number, became possible with the steam turbine and the water-tube boiler. The Froude numbers of present-day cargo ships, expressed as $\frac{V}{\Delta^{\frac{1}{6}}}$, are of the order of 3, those of liners 4 to 5, those of destroyers 8 to 10, and those of transport aircraft 125 to 250.

An indication of power requirements for different types of vehicle may be obtained by considering the thrust/weight ratio $\frac{P}{V\,W}$, where P is the installed power and W the weight, for each. It is found that the lowest ratio of $\frac{P}{V\,W}$ to speed, which is a measure of power economy, is reached by merchant ships, rail cars and commercial aircraft, and is about the same for each. On the other hand, the value of $\frac{P}{V\,W}$ for the aeroplane is about 10 times that for the ship. The high value for the aeroplane arises partly from its higher ratio of wetted surface to volume and partly from its high ratio of volume to weight. The $\frac{P}{V\,W}$ factor may be further reduced for the ship by reducing the speed. At the higher speeds it is also reduced by making the ship more slender, but this is not much help at slow speeds where the wave-making resistance is small. For this reason, the fat forms of the early sailing ships were not inefficient. It is of interest to note that the 100,000 ton ship will not fit in with the general trend of keeping the Froude number constant, but will obtain a low $\frac{P}{V\,W}$ factor by having a comparatively low speed.

The effects of cavitation on the speeds of ships and of compressibility on the performance of aircraft begin to be felt in each case, at about four-thirds of the present speeds. If such increases in speed were attained with the same Froude numbers as at present, that is to say, if $\frac{V}{\Delta^{\frac{1}{6}}}$ were kept the same, then weight increases of about $5\frac{1}{2}$ times would be involved, giving liners of 300,000 tons and aeroplanes of 700 tons. It might be thought that the square-cube law would rule out such increases, but its effects are offset by an improvement in structural efficiency which occurs as size is increased, due to the possibility of raising the average stress in the material without raising the maximum stress. Taking this into account it seems that size increases of the order of $5\frac{1}{2}$ times in weight are not impossible either for ships or aircraft.

The possibility of increasing the transport-momentum of ships by an increase of speed without a corresponding increase of size may also be investigated. If the Froude number were raised from 5 to 10, bringing the liner value up to that for the destroyer, then $\frac{P}{V\,W}$ would be increased 10 times, and the advantage of the ship over the aeroplane is thus lost. If the ship speed is to be increased without losing this advantage then it will be necessary to make the ship more slender. This involves some stability difficulties, but they would probably not be insuperable. It is significant that few large ships have yet been built with a displacement/length ratio of less than 50 and that this is also the figure for the Viking ships of a thousand years ago, whereas the eight-oared racing shell of to-day has a displacement/length ratio of 5.

The alternative means of avoiding the increase of wave-making resistance with speed is to go below the waves; but quite apart from the obvious disadvantage of the submarine as a merchant ship, it does not become advantageous unless very large speed increases are contemplated.

There remains the question of sea-going ability in rough weather. Whereas the aeroplane can often go above or around the storms, and the submarine below them, the surface ship must travel through them. It is often necessary for ships to slow down in these conditions, and thus lose the advantage of their design speed. The introduction of roll stabilisers has, to some extent, reduced this necessity, but pitching, which may involve the shipping of green water and "slamming," is more difficult to control. The longer ship is less prone to these troubles. It therefore seems that reduction of displacement/length ratio, from the point of view of increasing speed, would also be useful in reducing the adverse effects of bad weather.

RESEARCH IN FLUID AND SOLID MECHANICS

Lubrication, Seepage, Plasticity, Testing Techniques

A remarkably detailed picture of the research work which is going on throughout the world in the fields of fluid and solid mechanics emerged from the Ninth International Congress of Applied Mechanics held in Brussels recently. As might be expected, high-speed flow, where compressibility effects are important, was treated extensively, and a general review of recent advances in theoretical high-speed aerodynamics was given by Professor P. Germain of the Faculté des Sciences at Lille.

There was also much work reported on fluid problems where it is necessary to take into account several physical factors simultaneously, as for instance, in the compressible flow of a viscous fluid. Particular interest was aroused by a contribution of Professor N. J. Lighthill, of Manchester University, on the dynamics of a dissociating gas and the flow round a high-speed projectile. Other papers dealt with the behaviour of fluids in which the Newtonian viscosity and the compressibility are not sufficient to describe the physical characteristics.

A remarkable phenomenon in this connection was described by Professor M. Reiner of the Israel Institute of Technology. If two discs, one stationary and one rotating, are placed close to one another so that the thin film of air between them has to undergo a continuous rapid shear, then a pressure gradient can be built up at right angles to the shearing motion. This gradient can exceed that due to the usual centrifugal effects so that the device works as a centripetal, instead of a centrifugal, pump.

The papers on liquid motion discussed, among other matters, the generation of surface waves by moving obstacles and the motions of ships in rough water. A condensed version of a general lecture on "Ships," given by Mr. K. S. M. Davidson, is given in the preceeding article.

Among the papers on lubrication were several in which the hydrodynamic theory was developed without the usual simplifying assumptions. Such treatments bring the subject into the more general field of fluid dynamics. They are necessary if the effects of thermal gradients, both along and through the film, and the effects of inertia forces in high-speed bearings, are to be allowed for.

Contributions on flow through porous media included some on underground water seepage. In particular, Dr. H. Y. Hammad of Alexandria University discussed a problem which had been investigated in the Nile Valley, where the flood wave of the river was followed by a wave of water within the soil of the valley; the water storage thus obtained was useful in maintaining irrigation, by flowing back to the river when it was low. It was thought that pumping of the ground water might interfere with the backflow and so do harm to the irrigation, but it has now been found that if the pumping period is restricted to the three months preceding the flood, the backflow is not reduced.

On solid mechanics, much time was devoted to problems of plasticity. Professor R. Hill of Nottingham University gave a general lecture on "New Horizons in Mechanics of Solids," in which he described mathematical work on the behaviour of stressed solids, somewhat comparable to that mentioned above on non-Newtonian fluids. It sets out by assuming a substance which has elastic, plastic and viscous properties and examines how a given body of the material will behave when the stresses over parts of its surface and the velocities over other parts are specified. The general theory may be used to investigate the various special cases of, for instance, pure-elastic, pure-plastic, rigid-plastic, elasto-plastic and strain-hardening plastic materials. It may also be possible to show that different special cases will give similar behaviour, just as analogies between elastic solids and viscous liquids are known already.

Other topics in solid mechanics included testing techniques, among which may be mentioned a new type of compression test which has been used by M. Jean Lecavre, of the Research Centre of St. Gobain, Antony France, for brittle materials, such as glass, which give scattered and sometimes meaningless results when subjected to conventional techniques of testing; with the new test the results are repeatable and consistent. Modification of the analysis of impact test results was also discussed, and there were papers on dynamic testing, on stress-wave propagation, and on vibration calculations. Professor Dr. H. Mettler, of the Technische Hochschule, Karlsruhe, in a general lecture on "Forced Non-Linear Vibrations of Elastic Bodies," treated the problem of the strut which carries a sinusoidally-varying thrust; such a strut can, under certain conditions, vibrate in flexure at half the frequency of the exciting force. Vibrations of this type have been known for a long time and sometimes occur in engineering structures. Little work seems to be in progress on the subject apart from that at Karlsruhe.

The full proceedings of the Congress are to be published in due course.

PLATE BENDING BY ROLLING

USES OF VARIOUS TYPES OF MACHINE

By E. L. Tinley, M.I.MECH.E., F.INST.F.*

Concluded from page 595

ROLL MATERIALS AND ROLL-SURFACE FINISH

It is usual to supply rolls with not too fine a turned surface to assist them to grip the plate for a heavy initial pass. At the same time the lower rolls of the pyramid machine are usually provided with a number of longitudinal grooves to aid them in picking up the plate during rolling and also provide a gauge line for squaring up the plate initially. In special cases, however, when bending soft metals such as copper or aluminium, or where plate-surface protection is of first importance, as with stainless steel, specially-finished or even ground rolls may be necessary.

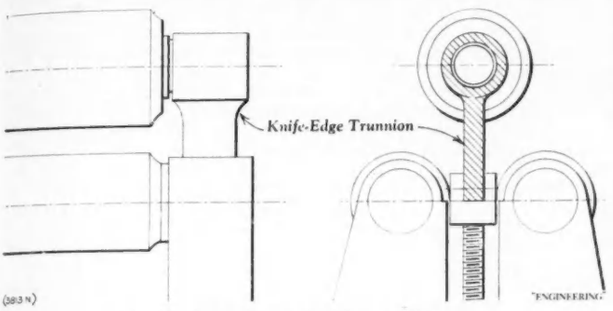


Fig. 22 Removal of completed cylinders.

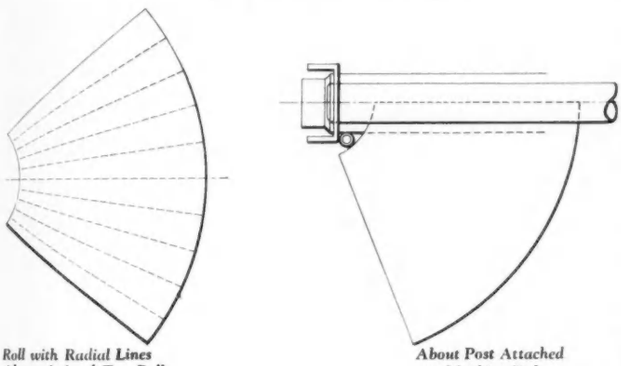


Fig. 23 Aids to cone rolling.

Normally a good quality medium-carbon steel forging may be employed. Special grade alloy-steel rolls are necessary for hot work, and especially for hard grades of plate or where excessive flexure is to be encountered. The modulus of elasticity varies little between different grades of steel, and while a good quality medium-tensile steel should be used, special reasons only justify the employment of high-grade alloys for the roll forgings.

WORKING WITH SHIM-PLATES FOR IRREGULAR SHAPES

In shipbuilding, especially on light vessel construction, plate must be bent to irregular curvatures along its length. This is achieved by rolling the plates with shim-plates of varying or appropriate thickness at those portions of the plate where the smaller radii are required. The pyramid machine offers greater flexibility for this kind of work owing to the balanced disposition of the rolls and improved support of the plate during working. In the structural fabrication field "lobster backs," the composite segments of bends for pipe work, are typical of this work which requires much skill.

FORMS OF ROLL DRIVE

In almost all pyramid rolls the bottom rolls only are driven, the top roll rotating idly by friction from the plate. The form of drive varies according to make, by gearing or by coupling spindles from a gearbox. Some manufacturers employ clutches in a gearbox, others rely on reversing motors with push button or tramway-type reversing controllers. All modern machines employ powered screw-down adjustment of the top roll and the advantage of clutches is that a non-reversing single motor only is required with simple stop/start switchgear. Shock loading in the drive is also less than when motors subjected to continual reversal, with electrical or mechanical braking, are employed. Clutches can be power-assisted to ease operator effort or for remote control at a more advantageous operating position. Where incorporated, however, clutches are not usually applied in machines of capacity greater than 1¼ in. plate thickness, owing to the size of clutch required beyond this point.

The choice of drive of pinch-type machines varies to a much greater extent, according to cost and requirements. Many machines of three and four-roll design have only the upper (non-adjustable) pinch roll driven, a convenient but inefficient form of drive. On light plate up to ⅜ in. it is permissible to drive both pinch rolls, but over this thickness "hunting" and plate slippage will occur owing to differential surface speeds, and if both rolls are driven a slipping clutch or similar device must be incorporated. The smaller the diameter of the work rolled and the thicker the plate, the greater will be the trouble experienced from the differential speeds of the inner and outer surfaces of the cylinder.

The objection to top pinch-roll drive only is that rotation of the bottom roll relies on an effective pinch pressure, in some cases excessive, causing objectionable roll-deflection and consequent barrelling. It is less effective for single-pass work and imposes a limitation on the minimum diameter of cylinders capable of being rolled. For such work there is advantage in driving all three rolls on a three-roll pinch machine with the compensation for slip already referred to for heavier sizes.

In the case of the four-roll pinch type machine, driving all three bottom rolls provides an ideal arrangement and causes no complication in changing the drive to the upper roll when using interchangeable top rolls. Driving the outer bending rolls ensures effective pick-up for severe bends and efficient drive of thin-gauge sheet. Where the rolls must possess a high surface polish and the coefficient of friction is low the drive to the three bottom rolls is particularly necessary.

The simplest method, which obviates the need for removal of any outer bearing mechanism is to employ a knife-type trunnion for the top roll outer bearing block (Fig. 22). Of necessity the trunnion neck will be narrow and deep, but it permits the complete cylinder to be drawn off at the joint, sliding over the trunnion neck without removing the bearing block. Manufacturers of plate rolls would not favour this as such a device is normally working at a negligible safety factor, and if a small degree of overload occurs it is frequently necessary to replace or re-weld the narrow neck of the trunnion.

The older forms of housing in which the upper half of the outer housing was pivoted and swung to one side are no longer countenanced and almost without exception "drop-end" bearings are employed. The time taken, therefore, to remove completed work is much the same irrespective of pinch or pyramid design. Provision is, however, made on some pinch-type machines for an automatic or semi-automatic release of the top or bottom roll at the time of removing the cylinder, the roll returning to its correct working position on the re-engagement of the swinging bearing automatically. In this there is some definite saving in time as the pyramid machine usually requires raising of the top roll to release the cylinder; the top roll must be raised in any case, however, to permit the entry of the next plate for working and such time is only measured in seconds, it is an insignificant proportion of the total bending operation.

BENDING CONES

When rolling cones or conical shapes in the lighter sizes of plate (up to ¼ in.) it is very much quicker to slew the plate about a post or loose attachment at one end of the rolls. Heavy plate normally requires marking out beforehand (Fig. 23) and, starting at the centre line, rolling in stages about consecutive axes or radial lines, a slow operation requiring re-alignment of the plate on the roll axis as bending progresses. The pyramid machine is to be preferred for this work.

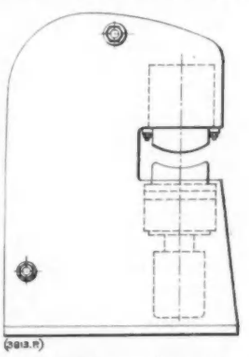


Fig. 24 Edge-curving press.

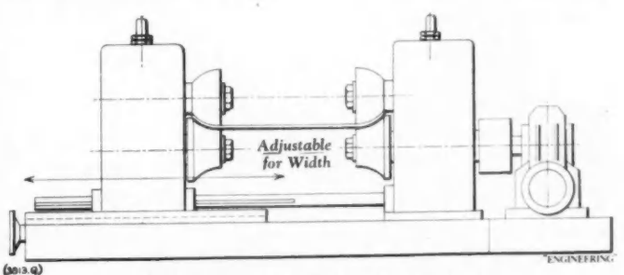


Fig. 25 Roller type edge-curving machine.

* Technical Director, Joshua Bigwood and Son, Limited, Wolverhampton.

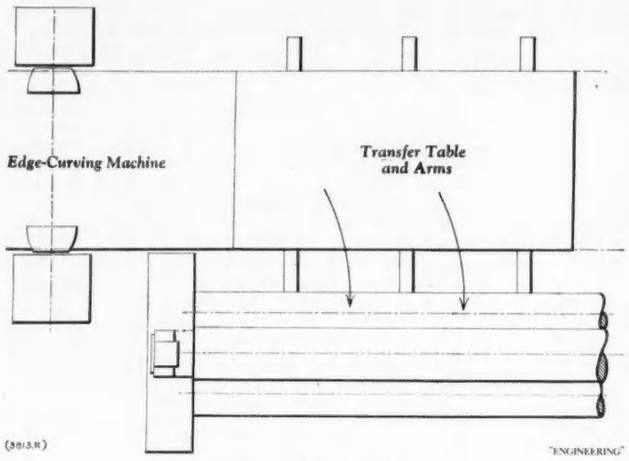


Fig. 26 Transfer table.

DUAL-PURPOSE MACHINES ADAPTED FOR BENDING SECTIONS

Certain classes of machines, invariably of pyramid design, are fitted with extensions on all three rolls, these extensions projecting beyond the outer housing and being keywayed to take composite rolls for bending sections. For smithy work this arrangement is adequate as its limitations are usually acceptable as a separate machine is usually unwarranted for the very occasional work necessary. The limitations are nevertheless severe in that—

(*a*) It is not possible with any ease to arrange the end housing for the removal of completed cylinders without stripping the housing down.

(*b*) The roll centres permit only a very limited size of section to be accommodated.

(*c*) It is necessary, during bending, to adjust the top roll of the plate rolls from some inconvenient position at the opposite end of the machine requiring, therefore, usually two operators. It is also slow and cumbersome.

Modern plate rolls do not normally provide for section bending, and in fact it is not a feasible proposition within the "drop-end" type of construction. An alternative method is to groove one end of the work-rolls to accommodate the legs of angles. This may be safe from a load point of view but tends to set up a heavy stress concentration at the groove in the roll which can be detrimental over a long period of time, and such a device is not, therefore, to be recommended. In addition the depth of the groove is very limited and transmits this limitation to the size of work that can be rolled. The same difficulties in operation apply as with the roll extension when making bending adjustments, and moreover it is not possible to make provision for counteracting the tendency of sections to "spiral" during bending.

INTERCHANGEABILITY OF TOP ROLLS

It is frequently necessary to provide machines with a spare top roll of smaller diameter for producing small diameter pipe work of lighter gauge. If this is required care should be taken in selecting the machine so that the changing of rolls can be carried out quickly and without recourse to special tools or undue disturbance of roll bearings. It is usually more convenient to accommodate spare top rolls on the pinch-type machine which has the bottom roll driven and not the top roll, avoiding thereby the need to re-couple the drive at each roll change. In pyramid machines the screw adjustment of the top roll, ideally sited between the bottom roll journals, may limit the minimum diameter of spare top roll that can be accommodated due to interference between the top roll outer bearing blocks and the bearing caps of the bottom rolls.

HOT WORKING OF PLATE

Plate of a thickness beyond the normal cold rating of the machine, special grades of high tensile steel, or exceptionally small-diameter cylinders in thick plate may need to be worked hot. It is most important that the rolls should be of a suitable quality of steel resistant to working at high temperatures without failure. Provision must also be made for pre-heating the rolls, either by gas jets or electrically prior to working. Such pre-heating must be for a sufficiently long period to raise the rolls throughout to an adequate temperature, otherwise a steep temperature gradient between the outer surface and the centre of the forging will induce excessive internal stresses, leading quickly to failure of the roll. In such work, strain gauges showing actual loadings on the rolls are of special value, as loss of temperature in the hot plate either during or awaiting rolling can lead to the machine being more highly stressed than anticipated.

FURTHER PRACTICES IN THE ELIMINATION OF FLAT ENDS

A number of methods are adopted to overcome the problem of flats at the butted joint, some by hand and others as a separate presetting operation with mechanical aid in the form of a press or rolls. These methods include the following:—

(*a*) Gripping the plate between the rolls and hammering the edges over the bottom rolls by hand to an approximate curvature. This is very detrimental to the machine and is slow and laborious.

(*b*) Using the top roll as a press-beam with a curved or angle-piece die between the bottom rolls and pressing the plate edges statically into the die piece. This method can be most injurious to the machine screw-down gear apart from any general overloading of the housings and rolls.

(*c*) Rocking the plate edges with a curved die plate or with wedge blocks.

(*d*) Rolling the complete cyclinder, welding the joint and re-rolling to remove flats.

(*e*) Rolling an excess length of plate to butt the flats and removing the flat ends by gas cutting, then butting the joints, tack welding and re-rolling.

(*f*) Bending to curvature in the pinch-type machine as already described.

(*g*) Pre-setting the edges of the plate in a press prior to rolling, either progressively through an edge-curving press (Fig. 24) or in the case of light plate in a press-brake, alternatively hot or cold in a four-pillar hydraulic press. Simple cast-iron or fabricated-steel dies may be used, each die covering a range of work diameter.

(*h*) Pre-setting in a roller-type edge curving machine (Fig. 25). This machine may be of one-stage or two-stage design, according to plate thickness and minimum radius required. The housing of one pair of rolls is fixed and the other is adjustable across the line of pass to suit varying widths of plate. Normal throughput speeds are of the order of ten to fifteen feet per minute though this can be increased for light plate, and such machines are capable of handling plate up to $\frac{3}{4}$ in. thick. Entry and exit tables are required, and for repetition work the machine may be installed adjacent to the plate rolls with raising and lowering transfer arms feeding the pre-set plate into the rolls (Fig. 26).

Like dies, each set of rolls will cover a range of radii, the fine control of the actual radius required being obtained by adjustment of roll pressure.

FLEXING ROLL MACHINES

The trend towards minimising the number of joints in pipeline work has dictated the need to roll pipes of small diameter, that is from 16 in. diameter upwards, in lengths of up to 40 ft. Such pipes may be from $\frac{1}{4}$ in. wall thickness up to $\frac{3}{4}$ in. wall in larger diameters. This can be achieved by employing artificially flexed rolls; thin pipe is bent cold, thick pipe is rolled hot. A further requirement, that of rounding or sizing the pipe after welding must be catered for and practical opinion diverges between pyramid and, in this case, four-roll pinch design. For the initial bending the pyramid form is generally more satisfactory and less costly in so far as the plate, long and narrow, is already pre-set at the edges in a press or through edge-curving rolls before entering the machine.

The problem of handling such unwieldy plate into the rolls is simply overcome by entry tables and a retractable top roll, with ejector arms for moving the finished tube on to the conveyor. The speed of withdrawal of the top roll, which may be actuated either by a hydraulic ram or by a draw chain, is very fast, and frictional resistance or damage to the plate being worked is reduced by a supporting roller, over which the roll rides.

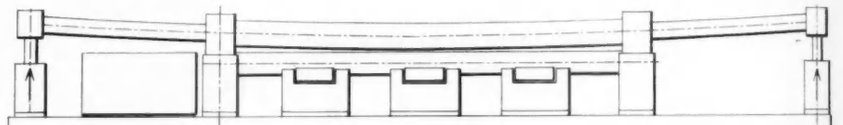


Fig. 27 Flexing top roll.

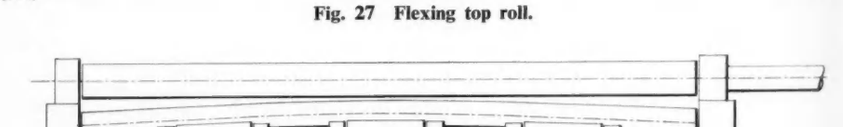


Fig. 28 Flexing bottom rolls.

As deflection increases rapidly with roll length, the problem of bending this long pipe is in counteracting the flexure of a long, small diameter top roll which cannot be supported in any way without preventing full diameter rolling. Two methods of countering this roll flexure can be adopted, one in which the top roll is artificially flexed downwards in the centre, the other in which the bottom rolls are artificially flexed upwards in the centre. A very brief description of both machines may be of interest.

In the first system (Fig. 27) the top roll is extended beyond its bearings at both ends and the end of each extension shaft attached to a vertically disposed hydraulic ram. Main bearings act as pivot points and vertical thrust by the hydraulic ram causes the roll to flex "banana" fashion. In rolling sufficient flexure

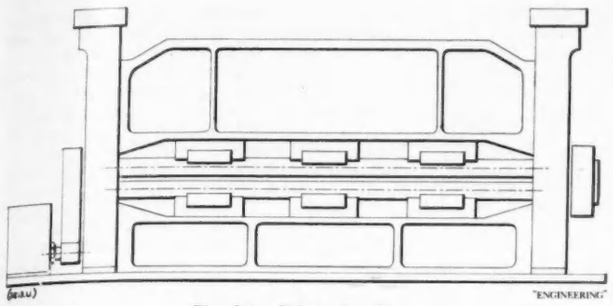


Fig. 29 Shipyard rolls.

is applied to balance the deflection due to the load in bending the pipe until the roll assumes a horizontal axis. This will produce a parallel, close-jointed tube or pipe. The bottom rolls are maintained horizontally by support rollers carried on the main cross beams of the bed. The top roll is not retractable on this type of machine but the roll can be continuous and the completed work drawn off.

The second form of construction (Fig. 28) does not pre-flex the top roll, but artificially flexes the bottom rolls by means of power adjusted, pressure support rolls. Coupled, differential adjustment, controls the movement of the support rolls so that correct flexure is applied. When rolling, therefore, both top and bottom rolls assume curved axes, but the centre-to-centre relationship is maintained the same at all points along the rolls, or if necessary adjusted during rolling to give the desired correction. Pivoting bearings must be employed, and the retractable-type top roll can be used. In this design there is greater flexibility of choice for employing different diameter rolls to increase the range of the machine.

After welding and annealing it is usually required to re-roll the pipe in a sizing and truing operation. A four-roll machine with pinch-rolls and two outer curving rolls is more efficient than a three-roll pyramid type, and again beam support and flexure of the rolls are incorporated in the design of such a machine.

Beam-supported or shipyard rolls, which are illustrated in Fig. 29, are of simple and rugged construction, employ supporting rolls and massive beams for all work rolls. This permits the machine to accommodate plate from 30 to 45 ft. in length and to accept short plates of a very much greater thickness than normal rolls. Small diameter work-rolls in pyramid disposition are carried in support rolls at from four to six points along their length. Bottom rolls are usually driven by heavy gearing at each end, the drive being brought by a cross coupling shaft to one end of the machine. Screwdown is fully mechanical and the machine can be used as a roll-press to apply a static load if required. The use of the machine is almost entirely limited to shipyard work.

THE MEASUREMENT OF TELEGRAPHIC DISTORTION

The accompanying illustration shows an instrument, which has been designed and constructed by Winston Electronics, Limited, Shepperton, Middlesex, for setting and testing telegraph equipment. It can be used to transmit several kinds of teleprinter signals, including a pre-set code character, at varying speeds, which can be accurately measured. When testing the actual teleprinter apparatus either almost perfect test signals can be sent or a known amount of distortion can be introduced. The equipment will also monitor both telegraph signals with only a negligible insertion loss and its own transmitted signal after it has passed over a line and back. A special socket enables high-speed relays to be set for neutrality and transit time, the latter being measured on the screen of the instrument.

CONSTRUCTIONAL DETAILS

As regards construction, the instrument contains an electronically-controlled transmitter which can send out five types of signals for either single or double current working and positive or negative mark. Among these is a continuous five-unit test character which is set by five toggle switches on the front panel. This character is preceded by a star signal of unit length and is followed by a space mark of two unit-length making a total of eight units. The transmitter can send a test signal into the line or to test relays and teleprinters, the output circuit consisting of a high-speed Carpenter telegraph relay, which is capable of supplying 20 milliamperes at $\pm$ 80 volts. The transmission speed is variable between 20 and 80 bauds, and the frequency stability, which is better than $\pm$ 0·1 per cent., is set by a precision potentiometer with an accuracy of $\pm$ 0·25 baud. The normal distortion of the transmitted signal is less than 1 per cent., but a pre-determined amount of start signal distortion, continuously variable from $-$ 50 to $+$ 50 per cent., can be introduced. The amount of distortion can be measured by monitoring the transmitter output on a cathode-ray tube in the receiver section of the equipment. This tube is 2¾ in. in diameter and has a graticule which is calibrated in percentage of distortion. The trace is usually suppressed so that the change-over points appear as bright spots.

RECEIVER SECTION

The receiver section of the instrument can be used in three ways: to monitor a telegraph signal which has been sent by another equipment into a line; to measure transmission speeds; and to monitor its own transmitted signals. When the first facility is being used the insertion of the equipment into a working line produces only negligible loss. The signals can therefore be observed without interrupting the normal working of a teleprinter system. Signal monitoring can be effected on either a circular or spiral time base. In the latter case the length of the spiral can be varied between 3 and 13 bauds for any speed of operation.

To measure transmission speeds it is only necessary to insert the instrument into the line and observe the picture of bright spots on the cathode-ray tube representing the alternating change-overs of the signal. The time base dial is then adjusted until the spots appear stationary when the speed can be read off in bauds. Apparatus is provided in the instrument to enable its own transmitted signals to be monitored after they have been sent through a length of line.

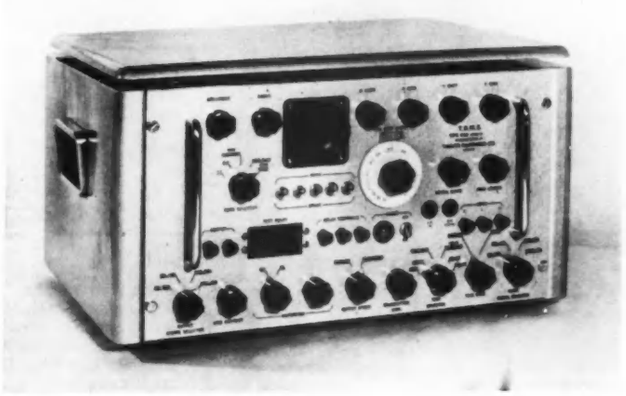
RELAY TESTING FACILITIES

The relay test socket is wired for the Carpenter relay to which all types of signal produced in the transmitter section can be applied. The contacts in this socket are automatically connected to the reversal and display section and facilities are provided so that the relay itself can be set to neutrality and its transit time measured.

As regards circuitry the time base oscillator is of the precision R-C design with a four-phase output. It drives the display cathode-ray tube to give either a circular or a spiral picture. The beginning and end of each spiral are determined by a gate generator, the beginning of the pulse from which coincides with the leading edge of the received start signal. The end of the gate is set by a control which provides for spirals up to 14 revolutions long. The frequency of the time base is set by a precision potentiometer.

The outgoing signal from the equipment, which is synchronised with the time base, can be obtained from the time-base oscillator or from a local oscillator with separate control. In either case the signal is fed through a squarer into a "ring of eight" circuit which is used to produce the test character of 8 bauds. Any type of signal can be selected by the coding unit and a distortion producing circuit, which is smoothly variable through a range of 50 per cent., can be switched on or off as required. The output signal is used to drive an internal-relay, the output from which is applied to the output terminal or to the test relay socket. A selector enables the output of the relay or the equipment under test or the input to the instrument to be connected to the test circuit.

The equipment is designed for connection to the alternating current mains and its power consumption is 180 watts.



Distortion-measuring equipment, manufactured by Winston Electronics, Ltd., for use on telegraph circuits.

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DUAL AIR-BRAKE SYSTEM

A vehicle-braking system, with independent circuits for the front and rear brakes, has been developed by the Westinghouse Brake and Signal Company, Limited, 82 York-way, King's Cross, London, N.1. A single engine-driven air compressor maintains the pressure in two otherwise independent reservoirs. Check valves at the entries prevent any return flow of air. Admission of air to the brakes is controlled by two separate valves which are built as a unit and operated by a single lever. The latter is moved either directly or through linkage by the driver's brake pedal, and can be mounted in any convenient position. Each circuit has a low-pressure warning indicator to give an alarm should the air pressure in the reservoirs fall below a set value. Where there are auxiliaries driven by compressed air, a third reservoir can be fitted, supplied from the same compressor and equipped with a charging valve to prevent loss of pressure in the brake circuits due to excessive use of the auxiliaries.

CABLE-ENTRY GLANDS FOR DEEP-SEA REPEATERS

CONNECTIONS TO WITHSTAND HIGH WATER PRESSURES

By V. G. Welsby, PH.D., B.SC. (ENG.), A.M.I.E.E., *and H. H. Grunwald*, B.SC. (ENG.), A.M.I.MECH.E.*

The recent successful completion of the first transatlantic telephone link† has drawn attention to a problem of increasing importance to-day, namely that of making electrical connections to electronic apparatus sealed in watertight housings which are capable of withstanding ocean-bottom hydrostatic pressures. Modern long-distance telecommunication cable links depend on "repeaters" which serve to boost the tiny signal currents at regular intervals along the route. In the case of a submarine cable these repeaters lie on the sea bed, possibly at depths where the water pressure is as high as several tons per square inch. Not only must the cable-entry glands prevent moisture penetration into the housing of the repeater, but their electrical insulation must be able to carry the direct-current power, possibly at several thousand volts, which is fed to the repeaters over the cable. This article is concerned mainly with the design and manufacture of the cable glands used in the British Post Office deep-sea type of submerged repeater but, as a matter of general interest, a brief description is also given of the repeater housing and the way in which it is assembled and sealed.

DETAILS OF REPEATER HOUSING

The electrical apparatus is contained in a sealed brass cylinder and this "apparatus unit" is fitted into the main housing which consists essentially of a hollow cylinder, machined from hot-drawn steel tube and closed at both ends by steel plugs or "bulkheads" through which the electrical connections must be made between the internal unit and the sea cable. Cylindrical extension-pieces, screwed on to the main casing, contain the clamps for attaching the repeater to the armour wires of the sea cable and the housing is completed by dome-shaped end-covers. Fig. 1 shows a completed repeater and gives some idea of its size. The method of sealing the housing and the arrangement of the high-pressure gland can be seen from the cut-away view, Fig. 2. The insulated cable core is tapered down to a diameter of 0·310 in. and passes through the steel bulkhead to the inside of the casing where it is jointed to a similar tail leading to the apparatus unit, part of which is also visible in Fig. 2.

The bulkheads, which register on seatings designed to withstand the axial thrust due to the water pressure, carry the special high-pressure entry glands for the 0·310 in. diameter cable tails and must themselves be sealed in position in the main cylindrical casing. Both the glands and the bulkhead-sealing joints must be designed so that not only can no actual water leakage occur but no appreciable diffusion of water vapour into the inside of the housing can take place, even after many years on the sea bed. Fig. 3 shows a view of a bulkhead complete with tail cable and high-pressure gland.

As can be seen from Fig. 2, the gland moulding is enclosed by a conical brass cover which serves the double purpose, firstly, of completing the outer electrical conducting path of the coaxial pair and, secondly, of providing a container for a thick insulating mixture of polythene and poly-iso-butylene in which the polythene gland moulding is immersed. This is yet another safeguard against failure, the intention being that any minute crack or leakage path would immediately be blocked by a highly-viscous insulating substance. Great care had to be observed in the choice of this compound because some substances, which would otherwise be suitable for the purpose, were liable to cause what is known as "environmental cracking" if allowed to come into contact with polythene, particularly if the latter happened to be subjected to mechanical stresses. A short length of flexible plastic tubing, sealed at one end, serves to equalise the pressures inside and outside the brass gland cover.

The actual seal between the skirt of each bulkhead and the casing is formed by a silver-soldering process, using carefully-controlled electromagnetic induction heating to raise the jointing region to the required temperature of 750 deg. C. and to maintain it at this temperature for a sufficient length of time to allow any trapped gas bubbles or flux particles to float to the surface of the molten solder. The primary object of the skirt of the bulkhead is to make the thermal-conduction path from the heated region to the cable gland and the apparatus unit long enough to avoid any undue temperature rise. A subsidiary skirt on each bulkhead contains a small vent hole which enables a low-pressure gas-leak test to be applied to the completed silver-soldered joints. The vent holes are subsequently used to flush the housing with dry nitrogen to remove any trapped moisture and are themselves finally sealed by steel plugs which are silver-soldered in place.

Immediately after sealing, but before the brass gland cover has been fitted, the sealed housing is immersed in water in a pressure vessel and subjected to a hydrostatic test pressure considerably in excess of that which it will have to withstand when it reaches the bottom of the sea. The test pressure so far used for working repeaters has been 1½ tons per sq. in., but tests on experimental housings have indicated that the silver-soldered bulkhead seals, like the glands, are satisfactory up to at least 5 tons per sq. in.

The extension-pieces, which are screwed on to the pressure-tight part of the housing after the latter has been sealed and pressure-tested, contain flexible poly vinyl chloride (p.v.c.) diaphragms (see Fig. 2). The purpose of these is to contain a viscous insulating liquid (poly-iso-butylene) which transmits the sea pressure to the bulkheads without actually allowing the sea water to come into contact with the silver-soldered seals. This removes any danger of electrolytic corrosion and, since the molecular size of the fluid mentioned is very much greater than that of water, it reduces the chance of leakage in the extremely unlikely event of a minute crack or pinhole appearing in a sealing joint.

CABLE-ENTRY GLAND

The cable-entry gland, although extremely simple in its final form, was the result of a great deal of patient research and development extending over many years. Several ideas were tried out at various stages but the design adopted was one based on the type of cable gland which had already been used for some years in the standard submerged repeaters laid by the Post Office in shallow-water cables around the British Isles.

In the design under consideration, the cable passes into the repeater through a ⅜ in. B.S.F. tapped hole in a cylindrical boss on the bulkhead known as a "gland stem." Although this could have been machined integrally with the bulkhead it was found more convenient for manufacturing purposes to produce it as a separate item and braze it into a recess in the bulkhead. The outer surface of the gland stem contains three annular grooves of approximately square cross-section, followed by a flange which serves to terminate the gland body. Between this flange and the base of the stem there extends a tube thick enough to withstand the external hydrostatic pressure and long enough to minimise the heat conduction from the moulding tool to the bulkhead during the injection moulding operation.

The gland body (see Fig. 4) is produced by injection-moulding polythene round the 0·310 in. diameter cable, placed in position inside the gland stem. The moulding tool is clamped against the shoulder of the gland stem and the cable is tensioned so that its centre conductor remains central throughout the whole of the moulding and cooling cycle. The injected polythene merges with the polythene insulant of the gland cable and causes it to penetrate into the screw threads of the entry hole. At the same time, the grooves of the gland stem are filled and a cylinder of polythene is formed surrounding the gland stem up to the flange.

RELIABILITY TESTS

A gland of the type described will meet practically all electrical requirements which can be met by the cable core itself, provided the manufacturing processes have been correctly carried out. The electrical power required to energise the repeaters is fed over the cable, and

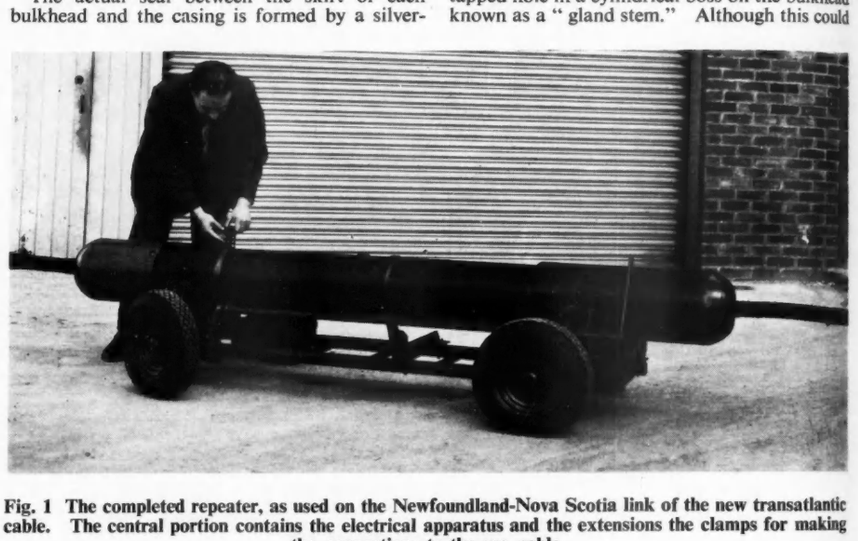


Fig. 1 The completed repeater, as used on the Newfoundland-Nova Scotia link of the new transatlantic cable. The central portion contains the electrical apparatus and the extensions the clamps for making the connections to the sea cable.

* The authors are at the General Post Office Engineering Department, Research Branch, Dollis Hill, London, N.W.2.

† See, for example, *Proc. I.E.E.*, vol. 102 (B), No. 2, pages 117-138, and articles to be published in *Proc. I.E.E.*, vol. 104 (B).

the direct-current potential difference between the inner and outer conductors may be as high as 3,000 volts. Any discontinuities in the polythene insulant of the gland will impair its electrical properties and may lead either to interference with the signals or even to complete breakdown of transmission. For this reason the injected polythene must merge completely with the original insulant of the gland cable and the completed moulding must be free from " voids " or gas pockets. A large number of glands have been tested and found to be at least as good as the cable core itself, as far as insulation and voltage breakdown figures are concerned, while the alternating-current voltage at which ionisation starts is generally slightly lower than for the cable, possibly due to the presence of sharp points in the profile of the tapped hole in the gland temp.

The hydrostatic pressure to which the glands are subjected in use tends to force the polythene through the hole in the gland stem. Although moulded " straight-through " glands of this type have been used successfully in shallow water, they would be useless at ocean depths because the axial force would be sufficient to cause " cold-flow " of the polythene, with the result that the cable core would eventually be pushed bodily through the bulkhead. The method which has been adopted for preventing this movement consists merely of tapping a $\frac{3}{8}$ in. B.S.F. screw thread in the central hole through which the cable core passes. As mentioned above, the injected polythene fills this thread and merges with the cable insulant, thus resulting in an external moulded thread which has the effect of distributing the axial force over a large area so that the shear stress in the polythene is too low to cause any appreciable " cold-flow."

Some glands have been on hydrostatic pressure test at 5 tons per sq. in. (corresponding to a sea depth of 4,000 fathoms) for over three years and have not shown a movement of more than a few thousandths of an inch. All glands subjected to this test (approximately 100 to date) have shown the same behaviour, namely a rapid initial movement settling to a hardly perceptible rate of " extrusion " after about a fortnight on test. It should be noted here that, theoretically, the length of the screw thread which supports the core should depend on the hardness of the polythene used. In the present design, however, a considerable factor of safety has been allowed in the length of thread and, provided the polythene used is of I.C.I. grade 2, or harder, no appreciable change in performance can be detected, even when polythene is used which has had a plasticiser added.

Sealing against the ingress of a liquid can only be achieved by providing a sealing pressure greater than the hydrostatic pressure in the surrounding liquid. In these glands, the hydrostatic pressure forces the polythene into the annular grooves machined on the outside of the gland stem and local stress concentrations produce the desired excess of pressure, so that the glands may be regarded as self-sealing. Initial sealing, while the hydrostatic pressure builds up, is provided by the thermal stresses locked in the polythene during the cooling period following the injection moulding. The sealing pressure due to these stresses is further assisted by a chemical bonding process applied to all the external surfaces of the gland stem with which the polythene will be in contact (see Fig. 4). The process consists of electro-depositing lead on the surfaces in question and afterwards converting the top layer of this lead to lead-peroxide (to which polythene can be bonded), followed by depositing a layer of polythene on the gland stem. Thus, by uniting the polythene, injected during the moulding operation with this layer of deposited polythene, a bond with the metal is achieved.

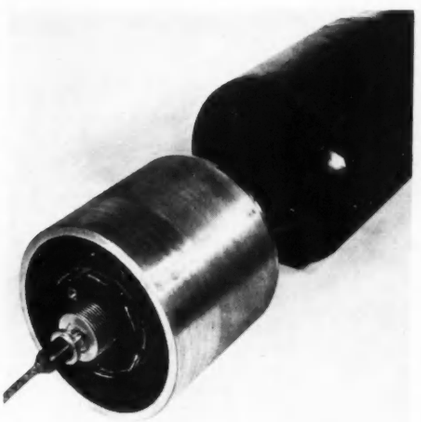


Fig. 3 Bulkhead and gland assembly, showing the tail cable for connection to the main sea cable.

It has proved extremely difficult to determine the rate of water penetration. All tests so far made have been carried out at a pressure of 5 tons per sq. in. with glands in which the chemical bond between the polythene and the steel stem had been deliberately omitted in order to obtain the most unfavourable conditions. The methods used in an attempt to detect moisture on the low-pressure side of the test glands are as follows:

(*a*) silica gel with an added indicator;
(*b*) a gravimetric method using calcium chloride as the hygroscopic material;
(*c*) a dew-point method; and
(*d*) a radioactive tracer method.

So far, for a period of over 12 months, method (*c*) has indicated that the rate of moisture penetration cannot exceed 4×10^{-8} gram per annum while method (*d*), with a sensitivity of $2{\cdot}7 \times 10^{-7}$ gram, has given a negative result over a period of about 6 months. Methods (*a*) and (*b*), which are necessarily less sensitive, have also given negative results.

GLAND MANUFACTURE AND INSPECTION

The housings for all the Post Office deep-sea type repeaters so far constructed (including 25 already in service and several spares) have been manufactured by Submarine Cables, Limited, and fitted with glands at the Post Office Research Station. This work included soldering the gland stems into the bulkheads supplied by the manufacturer, the chemical processing of the gland stem surfaces and the moulding and testing of the glands when completed. The polythene mixture used for the moulding has varied with the type of cable used. For the repeaters used on the Newfoundland-Nova Scotia link of the transatlantic telephone cable, for example, it consisted of I.C.I. grade 0·3 polythene with 0·07 per cent. of an anti-oxidant (diphenyl-paraphenylene-diamine) added, mixed with 5 per cent. of butyl-rubber to act as a plasticiser. The injection moulding was carried out in a brass moulding-tool, split along an axial plane to facilitate assembly and removal and fitted with electric cartridge-type heaters and channels for the circulation of cooling water. This moulding-tool was the product of a considerable amount of experiment, because the moulding problems encountered differed in several ways from those usually met in the plastics industry. The required standard of cleanliness and freedom from voids was exceptionally high and the injection pressure was severely limited by the

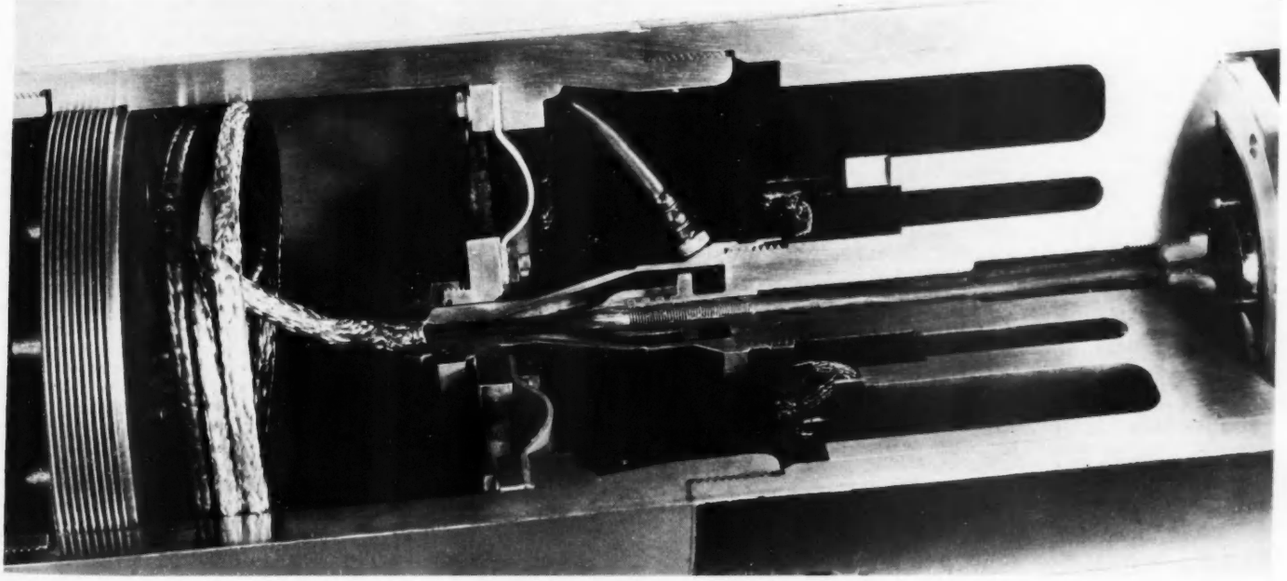


Fig. 2 The repeater, with part of the housing cut away to show the sealing arrangements. The " bulkheads " have to withstand the axial thrust of the water pressure existing on the sea bed. The gland moulding is contained in the conical brass cover which forms the outer electrical path of the coaxial pair and contains the insulating fluid.

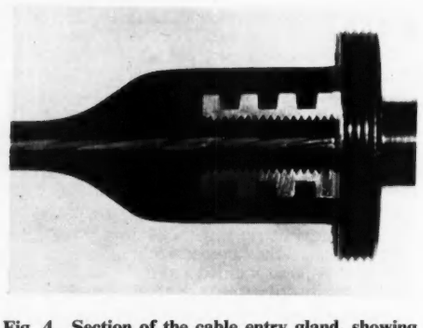
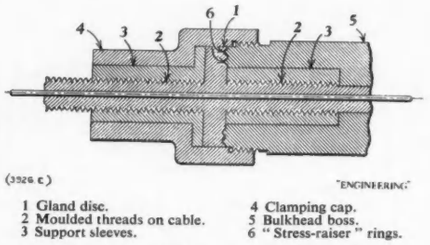


Fig. 4 Section of the cable entry gland, showing the tapped gland stem with its external grooves and the surrounding polythene.



1 Gland disc.
2 Moulded threads on cable.
3 Support sleeves.
4 Clamping cap.
5 Bulkhead boss.
6 " Stress-raiser " rings.

Fig. 5 Section of the improved " disc " gland which is more easily made and allows better inspection than the gland shown in Fig. 4.

fact that normal injection-moulding pressures would simply force the cable core out of the mould, breaking the copper strands forming the centre conductor. By very careful control of the temperature of the moulding tool it was finally possible to ensure that solidification of the injected material proceeded uniformly towards the injection point, thus eliminating the main cause of voids. By establishing, and then rigidly adhering to, a time cycle for the moulding process, very consistent results were obtained.

After moulding, the glands were inspected visually and radiographically, particular attention being paid to freedom from voids or dirt and proper adhesion of the polythene to the gland stem. A special radiographic technique had to be developed to achieve the degree of sensitivity necessary to reveal small voids within a material so transparent to X-rays as is polythene.

The glands were next subjected to a hydrostatic pressure of 5 tons per sq. in. for a period of three months. While under pressure, the glands were tested electrically by measuring their insulation resistance (specification value: greater than 20×10^{12} ohm) and the alternating-current voltage at which isonisation starts (specification value: not less than 3,000 volts at 50 cycles per sec.) as well as by applying a proof test of 40,000 volts (direct current) for 1 minute.

A considerable amount of equipment for handling the bulkheads (each weighing 80 lb.) and for testing the glands had to be specially designed and made. For example, a hydraulically operated lifting trolley was constructed, capable of positioning the bulkhead and attached moulding-tool accurately relative to the nozzle of the extruder used for the injection moulding. The same trolley was also arranged to carry the special X-ray camera so that the glands could be radiographed immediately after the completion of the moulding operation. An installation for the simultaneous pressure testing of up to 28 bulkheads and glands at a pressure of 5 tons per sq. in. was erected. This necessitated the design and construction of special stop-valves capable of controlling water at this pressure reliably, since no suitable valves could be obtained commercially at that time.

As is to be expected with a product requiring processes which are difficult to control and at the same time demanding such a high order of reliability, the rate of rejection was fairly high (approximately 30 per cent.). There is little doubt that many of the rejects would in fact have been quite adequate but were thrown out because of minor deviations from the highest standard obtainable. About two-thirds of the rejections were the result of the chemical processing failing to reach the high standard set, while the rest were due to accidental causes, such as the inclusion of minute impurities or of " hardbake " (flakes of oxidized polythene formed in the extrusion machine).

FUTURE DEVELOPMENTS

It will be apparent from the foregoing that the cable gland, developed specifically to meet the stringent requirements of submerged repeater engineering, has passed all its laboratory tests. It has further been shown that it is possible to produce these glands in quantity, though great care has to be taken and a fairly high rejection rate is to be regarded as inevitable in view of the standards which have to be set to ensure reliability of the product.

The search has nevertheless continued for a gland which will overcome two basic disadvantages of this type. These are, respectively, the difficulty of manufacture and the impossibility of examining, by direct methods, the portion of the gland cable enclosed within the metal stem.

A design has been evolved, and specimens have now been on test for about two years, of a gland which meets these additional requirements. The principles of this are shown in Fig. 5. The gland-body disc is formed integrally with the gland cable, so that (as before) the gland will meet all electrical requirements which the cable itself is capable of fulfilling. The disc, and the screw threads on either side of it, are moulded simultaneously on to the cable and these threads are fitted with tapped metal sleeves which prevent " cold-flow " of the polythene due either to the hydrostatic pressure or to the clamping pressure applied to the disc. The disc is squeezed against the bulkhead by means of a screwed cap, the contact surface of the bulkhead having annular " stress-raiser " rings. Initial sealing is obtained by the clamping pressure; the fact that part of the disc subjected to the external hydrostatic pressure is not supported will result in a sealing pressure in excess of the hydrostatic pressure. The stress-raiser rings will cause stress concentrations in the polythene, thus further increasing the sealing pressure. It will be appreciated that, with this design, the moulding is completed before the gland is assembled. This makes it possible to carry out visual and radiographic examination of the moulding and facilitates production.

CONCLUSIONS

Some details have been given of the problem of sealing the housings of deep-sea submerged repeaters against water penetration, and of a way in which this particular problem has been solved. There is little doubt that other applications exist, apart from submerged repeaters, where electrical connections have to be made through the walls of vessels subjected either to internal or external liquid pressure, and it is hoped that the work described in this article may be of some assistance in future developments of this nature.

Acknowledgements.—The authors wish to express their thanks to the Engineer-in-Chief of the Post Office for permission to publish this article and to acknowledge the contributions made by their colleagues at the Post Office Research Station, Dollis Hill. They are also grateful to Submarine Cables, Limited, who collaborated closely in the development of the repeater housing and who prepared the sectioned demonstration model illustrated in Fig. 2.

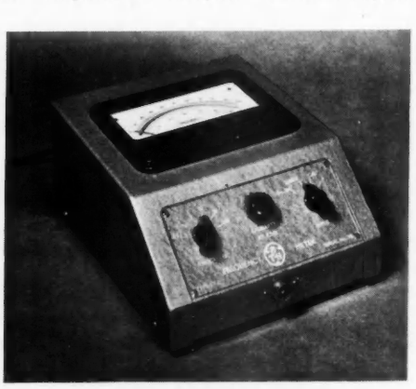
NEW FREQUENCY METER

Junction Transistors and Germanium Diodes Used

The accompanying illustration shows a new meter which has been developed by the British Thomson-Houston Company, Limited, Rugby, to give direct readings of frequencies from 15 cycles to 100 kilocycles in six ranges, the results being shown on the liniar scale of a moving-coil instrument. The new meter is interesting from the fact that it incorporates junction transistors and germanium diodes, while the accuracy is high and is independent of the input wave for a wide range of applied voltages. It is mains-operated and weighs only 9 lb.

Basically the instrument consists of a saturating transistor amplifier, which charges and discharges a capacitor on each cycle of the input voltage. As the mean current through the capacitor is proportional to the input frequency it can be rectified and shown on a direct-current moving-coil meter, which has been calibrated in cycles per second.

Any one of six frequency ranges, with full-scale deflections of 300 cycles, 1 kilocycle, 3 kilocycles, 10 kilocycles, 30 kilocycles or 100 kilocycles respectively, can be selected by a rotary switch; and on all but the highest range the accuracy of measurement is better than 1 per cent. of the full-scale deflection. Even on the highest range this accuracy holds good up to about 70 kilocycles. Because of the transistor characteristics measurements above this frequency may, however, be subject to slightly greater inaccuracies, but this should never exceed 5 per cent. at 100 kilocycles. To maintain the inherent accuracy of the equipment over a wide range of input voltages, a second switch enables one of two appropriate inputs to the amplifier to be selected to suit the applied voltage. As a result the instrument can be used to measure frequencies within the accuracies mentioned above with inputs ranging from 0·1 to 500 volts.



New B.T.H. frequency meter.

The instrument is essentially a current-operated device and consumes 40 milliamperes root-mean-square for a sine wave input and up to 110 milliamperes peak-to-peak for other wave forms. The long term stability of the meter is high and when using the internal battery as a source of reference voltage the calibration drift is negligible. The meter is primarily designed for use with the battery as a reference (a life of about 2,000 hours being achieved under continuous operating conditions) when the drift is less than 1 per cent. for a 10 per cent. variation in the mains supply voltage. It is, however, possible to make use of the mains voltage as a source of reference, but because of variations in the supply more frequent calibration is then usually necessary. Small variations are compensated for a " zero-set " control which is brought out in the centre of the point panel.

The new instrument can also be used for measuring the speed of rotating shafts. By placing the switch on the right-hand side of the panel a semi-conductor photo-cell input is made available. A combined photo-electric head, incorporating a light source and photo-cell, will also shortly be provided as an accessory; by focussing this on a graduated rotating shaft a reading will be obtained of the speed.

Book Reviews

TEACHING AERODYNAMICS

Solutions of Problems in Aerodynamics. By S. A. URRY. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2.* (32*s.* 6*d.*)

The growth of the aircraft industry during the last 20 years has caused a great increase in the demand for aerodynamicists and aeronautical engineers; to meet this demand, departments of aeronautics have been set up in many universities and technical colleges, with a consequent increase in the number of lecturers in the associated subjects. Unfortunately, the teaching of aerodynamics is more difficult than that of most engineering subjects, since, after the development of the basic principles, most aspects of aerodynamics require a good deal of mathematics. The lecturer in the subject must either devote a large part of the available time to the development of the mathematical side, thus reducing the amount of aerodynamics which can be taught in a given course, or else he must assume a certain level of mathematical knowledge in his students. This second alternative is probably justified for students at a university, but the average student taking the Higher National Certificate examinations needs some simplification of the mathematical work, since, in general, text-books on aerodynamics show little attempt to cater for the needs of such students.

The trend in the last few years towards the publication of books of solutions to examination questions in various subjects may be a partial answer to this problem. In many cases, a book of examples and their solution may act as a valuable addition to the text-book, particularly when up-to-date examination questions are incorporated, but there is the danger that it may be assumed to supplant the text-book entirely, and be treated as a short-cut method of passing a written examination. The student who relies too much upon a book of solutions to problems may well obtain only a superficial knowledge of the subject, in the form of a series of particular examination topics, sufficient to pass the average written examination, but his ability to apply his knowledge of the subject will be questionable.

This new book on the solution of problems in aerodynamics is, however, an improvement on many books of this type, in that it is written with the needs of students of limited mathematical background in mind. The standard throughout the book is that which one would expect for a student taking the examinations of the various engineering institutions, and the presentation is extremely clear. It is noteworthy that dimensional analysis and dynamic similarity are introduced at an early stage, together with an insistence throughout the book on the checking of dimensions at various stages in the working of a problem. Too often, the author of a text-book stresses the importance of dimensions in his introductory chapter and then omits them in the text and worked examples. The concepts of circulation, lift and vorticity are dealt with in a clear manner, and a simple explanation of the Joukowski transformation is given, with a number of examples on its use. The final chapter is devoted to the elements of boundary-layer theory and the problems of compressible flow.

It is a pity that this book which, as the author states, is intended to supplement lecture notes of a formal text-book, should be so expensive. Recent inquiries at Cambridge have revealed an average annual expenditure per student on books of just over £2 per head, and it seems unlikely that many technical college students will be able to afford books of this price. With the apparent continuous rise in book costs, the solution might lie in the use of cheaper paper-backed text-books, such as are common in France and have been tried more recently in the United States.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Wrought Titanium. IMPERIAL CHEMICAL INDUSTRIES, LTD., Imperial Chemical House, Millbank, London, S.W.1. This is the second edition of the I.C.I. publication dealing with the properties, manipulation and uses of wrought titanium, and it contains a considerable amount of additional information. There are ten chapters, the first five of which deal with the physical and mechanical properties of the metal. Corrosion resistance of titanium and the question of future developments in the titanium alloy field also receive attention in this first section of the publication. Titanium can be machined, cold formed, hot worked, welded and generally manipulated by methods similar to those used for other metals, but special techniques are necessary, and the final five chapters of the publication are devoted to these matters, which are of particular interest to users of the metal. The whole range of machining processes used in engineering shops can be applied to titanium, subject to certain modifications in procedure, and the necessary details are given. Similarly, the metal can be hot worked quite easily, but it tends to suffer from oxygen contamination, and requires careful heating. A separate chapter deals with de-scaling and surface treatment. Forming operations such as pressing, spinning and stretch forming are also the subject of a chapter, and the technical information concludes with a section on welding, brazing and soldering. The publication also contains a number of weight/size tables, for titanium bar, sheet, plate, wire and tube. Brochure of 68 pp. with illustrations showing the production of wrought titanium and some examples of its uses.

Cutting Fluids. MOBIL OIL CO. LTD., Caxton House, London, S.W.1. Industrial Technical Bulletins Nos. 14 to 19. Solvac standard soluble cutting oil for ferrous and non-ferrous metals; Solvac Double One high-grade soluble cutting oil for ferrous and non-ferrous metals; Solvac T translucent soluble cutting oil for ferrous and non-ferrous metals; Sultran heavy-duty straight cutting oils for carbon steels, high-tensile alloy steels, stainless steels, the Nimonics and titanium alloys; Vacmul triple-purpose straight cutting oils (cutting fluid, lubricant and hydraulic oil) for ferrous and non-ferrous metals. Series of technical information sheets.

Photogrammetric Plotter. HILGER & WATTS LTD., 98 St. Pancras-way, Camden-road, London, N.W.1. The Thompson-Watts photogrammetric plotter, a 1st-order stereoscopic instrument for mapping to any desired scale from air photographs and for carrying out aerial triangulation. Leaflet giving brief description, operation and installation data.

Diesel Crawler Tractor. JOHN FOWLER & CO. (LEEDS) LTD., Hunslet, Leeds 10. Challenger 2 crawler tractor for heavy agricultural and medium industrial duties. 65 h.p. Leyland Diesel engine. Maximum drawbar pull 13,600 lb. Six forward, four reverse speeds. Illustrated leaflet and specification.

Flame Failure Protection. RADIOVISOR PARENT LTD., Stanhope Works, High Path, London, S.W.19. Flamestat type FU.56 flame-failure safeguard for oil, gas, or pulverised fuel burners. Photocell sensitive to all colours of flame operates from flame modulation, not light intensity. Illustrated leaflet giving installation data.

Smoke Density Meter. BAILEY METERS & CONTROLS LTD., Progress Way, Croydon. Bailey smoke density meter measures continuously smoke density in chimney or duct by means of photo-electric cell. Provision for visual or audible alarm signal. Illustrated leaflet giving installation, maintenance and technical data.

Benzole Recovery and Rectification. CHEMICAL ENGINEERING WILTONS LTD., Bird Hall-lane, Cheadle Heath, Stockport. The UCB-Wilton process for benzole recovery and rectification. Operating costs reduced by using residual heat of de-benzolised wash oil for benzole rectification. Illustrated leaflet describing process.

Airborne Geophysical Prospecting. HUNTING GEOPHYSICS LTD., 6 Elstree-way, Boreham Wood, Hertfordshire. Combined prospecting with electromagnetic detector, magnetometer and scintillation counter installed in Dakota aircraft. (See article in ENGINEERING of August 24, 1956, page 226.) Descriptive illustrated brochure.

Structural Timbers. COLONIAL DEVELOPMENT CORPORATION, 33 Hill-street, London, W.1, and BRITISH GUIANA TIMBERS, LTD., Houston Sawmills, Georgetown, British Guiana. Greenheart from Demerara, its properties and uses. Availability increased by new mills established at Georgetown. Illustrated booklet.

Tub and Mine Car Controllers. HADFIELDS, LTD., Sheffield. Automatic tub controllers of the rigid and spring loaded types. Improved designs necessitated by the increase of mechanisation in mines and by the use of longer tubs. Technical details with drawings of constructional arrangements. Illustrated leaflet No. 523.

Flexible Hoses. COMPOFLEX CO. LTD., 23-25 Northumberland-avenue, London, W.C.2. Flexible tubing and hoses—composite (plastics reinforced with spiral wire), metallic, rubber, plastics, and special-purpose; notes on maintenance; price list. Illustrated catalogue giving technical data.

Builders' Tools and Plant. GEORGE PIKE, LTD., Alma-street, Birmingham, 6. Small tools of all descriptions for the builder and contractor. Also light wagons, generators, compressors, lights, road signs, industrial clothing, temporary accommodation and so on. Illustrated catalogue.

Wheeled Diesel Tractor. MARSHALL SONS & CO. LTD., Britannia Works, Gainsborough. 70 h.p. Leyland Diesel tractor M.P.6, for large-scale cultivation. Maximum drawbar pull 9,800 lb. Six forward, two reverse speeds. Illustrated leaflet and specification.

Industrial Safety Spectacles. THE HADLEY CO. LTD., Portsmouth-road, Surbiton, Surrey. Illustrated catalogue giving particulars of various types of industrial safety spectacles, trades requiring protection, legal requirements, recommended frames and specifications.

Self-Reset Timer. RODENE ELECTRICAL CO. LTD., 579 London-road, Isleworth, Middlesex. Synchronous motor driven timer with re-setting device to that after completion of timing cycle it will return to its original pre-set position. Illustrated leaflet.

Prestressed-Concrete Bridges. MCCALLS MACALLOY LTD., Templeborough, Sheffield. Prestressed-concrete bridges, arches, silos, etc., using the Lee-McCall system, erected in the United Kingdom and overseas. Illustrated reprints from the technical Press.

Woodworking Machinery. BURSGREEN SALES, LTD., Canal Works, Halifax. Details of a range of machines for sawing, planing and thicknessing, moulding, mortising and tenoning. Folder with an illustration and brief technical details of each machine.

Arc Welding Electrodes and Welding Rods. HADFIELDS, LTD., Sheffield. Arc welding electrodes and welding rods for hard-surfacing and mechanisation. Characteristics, sizes and applications of solid drawn and tubular types. Illustrated leaflet No. 521.

Plant Construction. HEAD WRIGHTSON PROCESSES LTD., Teesdale House, 24-26 Baltic-street, London, E.C.1. Plant and equipment for refineries, power stations, chemical and nuclear-energy installations. Brief history of company. Illustrated brochures.

Limits and Fits Pocket Calculator. COVENTRY GAUGE & TOOL CO. LTD., Fletchamstead Highway, Coventry. Pocket calculator, for shaft limits and fits, to B.S.1916:1953. On one side, clearance fits; on the other transition and interference fits.

Air Filters. VISCO ENGINEERING CO. LTD., Stafford-road, Croydon. Oil-wetted air filters, "Standard" type for ordinary commercial use and "Duplex" for high filtering efficiency. Descriptive illustrated brochure with technical data.

Cutting, Drawing and Heat-Treatment Oils. AMBER OILS LTD., 11A Albemarle-street, London, W.1. The properties and uses of Amber cutting and drawing oils and heat-treatment oils. Operation manual giving practical guidance.

Fire Alarms. FIRE PROTECTION ASSOCIATION, 15 Queen-street, London, E.C.4. "Fire Alarm Systems in Buildings"—recommendations on type and installation. Technical information sheet.

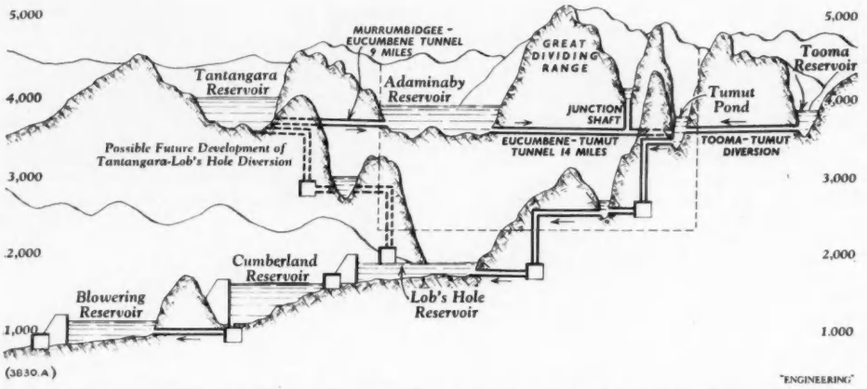


Fig. 11 The Adaminaby reservoir is the main storage for the northern half of the Snowy Mountains Scheme—the Eucumbene-Tumut development. The works in the area enclosed by a single broken line are being constructed now.

The Snowy Mountains Scheme—3

EUCUMBENE-TUMUT DEVELOPMENT

MAIN REGULATING STORAGE OF THE SCHEME POWER STATIONS UNDERGROUND

The Eucumbene-Tumut development covers the northern section of the Snowy Mountains scheme in South-Eastern Australia. It involves the damming of the Eucumbene, one of the main tributaries of the Snowy River, to form the Adaminaby reservoir. The water from this reservoir will flow through a 14 mile tunnel under the Great Dividing Range to the headwaters of the Tumut River, a tributary of the Murrumbidgee. The water will then flow through five power stations in the Tumut Valley with a total installed capacity of 1,070 MW, after which its regulated flow will be used to irrigate new farms in the dry but fertile lands of the central and lower Murrumbidgee.

The geographical position of this section is shown in Fig. 2, in the first article on the scheme, published in ENGINEERING for August 24, page 232, and a diagrammatic representation of this section is shown in Fig. 11 on this page.

The Adaminaby reservoir, with an initial capacity of 3 million acre-feet, will serve as the main regulating reservoir of the Eucumbene-Tumut development. It will receive water from the Tantangara reservoir, and by a system of valves described below it can also receive water from the Tooma reservoir and the Junction Shaft diversion. The object of these arrangements, at first sight rather elaborate, is to preserve the greatest possible amount of water in years of good rainfall for release in years of bad; by connecting all the reservoirs together, with the Adaminaby as a main storage, the regulation system is very flexible.

Work is now proceeding on the Adaminaby dam, the Eucumbene-Tumut tunnel, and T1 power station; these works are enclosed by a single broken line in Fig. 11. The next stages of the development, particularly the Tooma-Tumut diversion and T2 power station, are being closely investigated and planned. A detailed description is given below of the work in progress, and a more general account of those parts of the development yet to be started.

ADAMINABY: THE MAIN STORAGE

The Adaminaby dam is an earth and rock-fill dam of crest length 1,900 ft. and maximum height above the river bed of 390 ft. Construction was begun by the Public Works Department of the Government of New South Wales, but it was recently decided to put the completion of the dam out to tender. The successful tenderer, to whom a contract was awarded during May, 1956, is the Kaiser-Walsh-Perini-Raymond Joint Venture*, an American firm that has already been awarded a number of contracts in the scheme.

During construction, the river is being diverted through a concrete lined tunnel in the right abutment of the dam. To this tunnel will be added an upstream portal, a gate chamber, an access shaft at the centre, and an energy dissipator at the downstream end, so that it can be used as a permanent outlet for the dam when the reservoir starts to fill. Two 9 ft. by 20 ft. fixed wheel gates will be installed in the gate chamber during the initial filling period to deal with floods. For permanent use these will be supplemented by two 6 ft. by 7 ft. 6 in. high-pressure slide gates immediately downstream of the larger gates.

Because floods are to be released through the outlet tunnel no provision is made for a permanent spillway. A natural saddle on the north-eastern side of the reservoir will serve as an emergency spillway, and excessive flood waters will discharge over this into the Murrumbidgee.

As the Tumut River potential becomes more fully developed, the Authority may consider raising the crest or providing erosion-protection works at the crest so that the maximum operating level may be raised by 10 or 12 ft. This will increase the storage capacity from 3 to 3½ million acre-feet. When the height of the dam is increased in this way, a low spillway structure will have to be built across the emergency spillway saddle.

TWO-WAY FLOW THROUGH TUNNEL

Flow from the Adaminaby reservoir is through the Eucumbene-Tumut tunnel to the Tumut pond, and from there through pressure tunnel and shaft to T1 power station. All these works are being constructed now: the tunnel, Tumut pond dam and pressure tunnel by the Kaiser-Walsh-Perini-Raymond Joint Venture, and the pressure shaft, power station, and tailrace tunnel by a group of French firms, Etudes et Entreprises.*

* The American group comprises: Henry J. Kaiser Company; Walsh Construction Company; B. Perini & Sons Incorporated; Raymond Concrete Pile Company of Delaware; General Construction Company; Bates & Rogers Construction Corporation and the Arthur A. Johnson Corporation with Henry J. Kaiser Company as Sponsors. The French group consists of: Compagnie Industrielle de Travaux; Entreprise Fougerolle pour Travaux Publics; Société Generale d'Entreprises; Etudes et Entreprises; L'Entreprise Industrielle and Société Nationale de Travaux Publics.

The tunnel has a system of valves by which water can be diverted from the Tooma reservoir or from the Junction Shaft diversion back to the Adaminaby reservoir. The total fall of the Tumut from the Adaminaby reservoir to Tumut pond is only 72 ft., so that under suitable conditions the head of water at the Tooma reservoir or the Junction Shaft diversion will be sufficient to force water back to the Adaminaby reservoir. The Tumut River, as shown on Fig. 2, page 232, runs from above the Junction Shaft to Tumut pond and then down the Tumut Valley. The Shaft serves two purposes: in the construction of the tunnel it makes two more working faces available; and in the hydraulic operation of the completed system excess flow in the higher reaches of the Tumut can be diverted down the shaft and so back to the Adaminaby reservoir.

The tunnel is 13·8 miles long, circular in section with a diameter of 21 ft., and concrete lined throughout. Work is proceeding rapidly at the Eucumbene portal and at the two faces driven outwards from Junction Shaft. Fig. 12 shows the superstructure at the shaft, and also shows the restricted working area; the Tumut River flows in from the right and the Happy Jacks River, flowing in from the left, has been covered over to provide additional storage space.

An intake structure at the Eucumbene portal houses a 12 ft. 10 in. by 21 ft. coaster-type gate for emergency regulation of the flow and for shutdown for tunnel maintenance; an emergency bulkhead gate of the same dimensions allows maintenance to be done on the coaster gate. The gate shaft is about 600 ft. downstream of the intake screens and is 24 ft. 6 in. in diameter and 600 ft. high. The trashrack is a "cage type" with screens in both sides and top, the clear spacing of bars in the screens being 5 in. Between the trashracks and the main tunnel there is a cut-and-cover section to ensure that possible slides of the hillside material cannot block the trashracks. As the tunnel is designed for reversal of flow no provision is made for cleaning of the trashracks.

CYLINDER GATE AT FOOT OF SHAFT

The Junction Shaft diversion dam is to be a concrete arch gravity dam 95 ft. high with a crest 260 ft. in length. It has an overflow spillway with a capacity of 63,000 cusecs and is equipped with two 4 ft. diameter river outlet gates. The crest of the shaft is 300 ft. above the Eucumbene-Tumut tunnel invert, and the shaft intake is screened by a vertical trashrack.

Detailed studies were made to decide the best type of gate to admit water from Junction Shaft to the tunnel; the main problem was to prevent air becoming entrained by the water, because the air could collect in large pockets and be expelled with explosive force past the control gate and from the tunnel exit, causing a surging of the tunnel and shaft flow. Such pressures could damage parts of the system. Tests on models showed that the cylinder gate prevented entrainment of air, and this type of gate was therefore adopted. The opening of the gate will be automatically controlled by the level of the water in Junction pond. Starting or stopping of this automatic operation will normally be effected from T1 power stations, but the gate may also be operated from a local control. Gate-position indicators will be installed both at T1 power station and at Junction Shaft.

The Tumut River outlet portal is ¾ mile upstream from the Tumut pond dam. A short concrete channel in the river bed at the outlet will prevent erosion of the river bed and a transition from circular tunnel section to channel section is to be incorporated in the outlet works. A hydraulically operated roller coaster gate, 12 ft. 10 in. by 21 ft., 600 ft. upstream from the tunnel outlet, will close the tunnel while flood flows from the Upper Tumut or the Tooma Rivers are being diverted back to the Adaminaby reservoir.

BEHAVIOUR OF A THIN ARCH DAM

The Tumut pond of 43,000 acre-feet capacity will form the regulating pondage for T1 and T2

power stations. The dam (the site of which was shown in Fig. 2 of the first article on the scheme, page 232) will be a concrete arch structure with crest level 290 ft. above the river bed, crest length 650 ft., and crest width sufficient to take a 12 ft. wide roadway with a 3 ft. wide footpath on each side.

The main grout curtain will consist of holes drilled and grouted from the foundation gallery. These holes will be drilled at about 5 ft. spacing and to varying depths up to 125 ft., but if foundation conditions indicate that it is necessary grout holes will be drilled to a maximum depth of 210 ft. There will be contraction joints across the dam at intervals of 47 ft. and all these joints will be grouted to ensure a monolithic structure.

A chute spillway on the right abutment of the dam will be able to discharge 68,000 cusecs with reservoir level 5 ft. above full supply level. It will be controlled by two radial gates 47 ft. wide by 30 ft. high. Two 84 in. diameter river outlet pipes through the dam will have a combined discharge capacity of 7,200 cusecs under maximum reservoir level. A ring-follower gate and a jet-flow regulating gate will be installed at the outlet of each conduit.

Because the Tumut pond may be emptied or filled in a matter of days there is a unique opportunity to obtain basic data on the structural behaviour of thin arch dams. To this end a variety of instruments, including strain gauges, thermometers, and uplift measuring pipes will be installed within the dam.

Groups of strain gauges will be installed as follows:—

(*a*) one installation at each abutment at elevation R.L. 3,650, where maximum arch stresses are expected;

(*b*) one installation at the centre of the dam at the base where maximum cantilever stresses are expected;

(*c*) one installation at the centre of the dam at elevation R.L. 3,650, directly above the second installation at the base of the dam.

The behaviour of one arch may therefore be studied at three places and the maximum cantilever at two elevations. At each of the four principal locations three strain gauge groups will determine the stress distribution through the dam. In each group 12 individual strain gauges will be embedded in a cluster, in order to give the complete information needed for the determination of the stress, which is of three-dimensional character in a structure of this type. Readings of all strain gauges will be made at a terminal board which has been erected in the foundation gallery.

Temperature is one of the principal factors governing volume changes; thermometers will be placed at vertical intervals of 25 ft. at the upstream face of the centre block, and within the dam at varying distances from the upstream face at vertical intervals of 75 ft. Thermometers will also be placed near the abutment strain gauge installations at R.L. 3650. Readings of the thermometers will be made at terminal boards in the gallery with the exception of the uppermost group, which will be read at a terminal board at the crest of the dam.

Targets will be installed at three levels in the downstream face of the dam at the centre of the dam, the abutments, and the quarter points. Theodolite readings from two base lines downstream of the dam will enable deformation of the targets on the face to be calculated. There will be three uplift pressure measuring installations, one at the centre of the dam and two at the abutments, each consisting of three pipes; readings from these will be made in the foundation gallery.

From the Tumut pond, a 21 ft. diameter concrete-lined pressure tunnel runs 8,000 ft. to the surge tank for T1 power station. The surge tank is of the two-chamber type with connecting riser shafts 18 ft. in diameter and about 250 ft. high. The lower gallery of the surge tank is a circular concrete-lined tunnel 21 ft. in diameter and 120 ft. long, and the upper chamber is 50 ft. in diameter and 120 ft. high.

Fig. 12 The superstructure at Junction Shaft. The shaft makes available two more faces for drilling the tunnel, and will form a part of the hydraulic control system. The Happy Jacks River, flowing in from the left, has been covered over to provide storage space in a very restricted area.

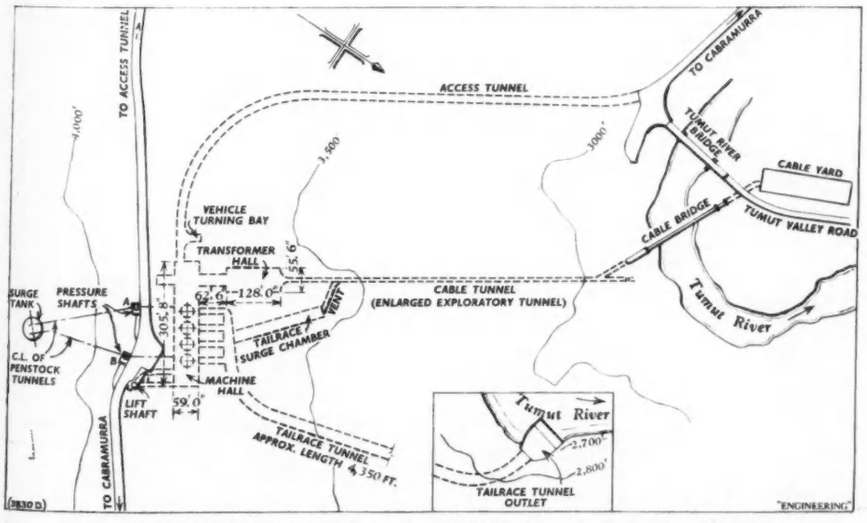


Fig. 13 The general position of T1 power station, 1,200 ft. below the right bank of the Tumut River.

From the Tumut pond, a 21 ft. diameter concrete-lined pressure tunnel runs 8,000 ft. to the surge tank for T1 power station. The surge tank is of the two-chamber type with connecting riser shafts 18 ft. in diameter and about 250 ft. high. The lower gallery of the surge tank is a circular concrete-lined tunnel 21 ft. in diameter and 120 ft. long, and the upper chamber is 50 ft. in diameter and 120 ft. high.

At the downstream side of the surge tank the tunnel bifurcates into two 12 ft. diameter penstock tunnels leading to the vertical pressure shafts. These shafts are also 12 ft. in diameter and are over 1,200 ft. deep from ground-surface level to the entrance to the power station. The section of the shafts below the penstock tunnel connections and through which the water flows is 800 ft. deep and steel lined with concrete backing at least 12 in. thick. The steel lining varies in thickness from $\frac{3}{8}$ in. at the upper end to $1\frac{1}{8}$ in. at the lower and is designed to be safe against buckling due to external pressure during dewatering. About 60 ft. upstream of the entrance to the power station each of the pressure shafts bifurcates, forming the four penstocks to the four units of the power station.

320 MW UNDERGROUND POWER STATION

The T1 power station is being built 1,200 ft. below the natural surface of the right bank of the Tumut River. It consists of a main generator hall which also contains the control room, and a transformer hall at right angles to the generator hall. The output from four 80 MW 12·5 kV generators is fed to six single-phase 56 MVA transformers, each having two 12·5 kV low-voltage windings and one $330/\sqrt{3}$ kV high-voltage winding.

Access for vehicles is by a tunnel 1,300 ft. long with a grade of 1 in 8, and for staff, visitors, and light equipment there is a 1,200 ft. lift which can carry 3 tons or 17 people. The only other access is through the cable and ventilation tunnel. The road to the entrance for vehicles has been made of a suitable grade, width and carrying capacity to take the Authority's Thornycroft heavy transporter, which will carry all heavy equipment to the station.

The general position of the power station and a more detailed plan are shown in Figs. 13 and 14. The machine hall is 306 ft. long, 55 ft. wide and 110 ft. high, and the transformer hall 127 ft. long, 55 ft. wide and 40 ft. high. The rock in the roof of the machine hall will be supported by heavy concrete arch ribs at 12 ft. centres. Under the ribs an arch shell 9 in. thick forms a monolithic structure with the ribs. Steel wedges are driven between the concrete arch ribs and the rock at 6 ft. intervals along the ribs; these ensure a tight contact between the ribs and the rock so that no large bending moments can be developed in the ribs under unsymmetrical, active rock loads. This " ribbed " method of construction, which is repeated in the transformer hall, permits free draining of the rock and allows the rock to be inspected regularly.

The whole station has been designed to accommodate the generators, transformers and ancillary equipment as compactly as safety allows. The top floor contains the workshop and assembly bay, stores, transformer hall and control block. The next floor below contains the generators, oil and air coolers and impulse exciter sets; the next lower is the turbine floor and contains turbines, cooling water pumps for turbines, generators and transformers, the compressors and receivers for the station compressed-air system and the cooling-water pumps for the air-conditioning system. Lowest is the valve floor, which is a continuous gallery on the upstream side of the station containing the main inlet valves and their associated operating gear. Short branches from this gallery give access to the underside of the turbines, and are the means of installation and removal of the lower turbine parts, including the runners.

In separate pits below the valve floor are the station drainage pumps, the emergency drainage pumps, and the emergency ejector-type pumps. Downsteam of these pits is a continuous gallery which forms the station drainage sump, the invert of which is below all other spaces and equipment in the station.

Control cables and busbars between generators

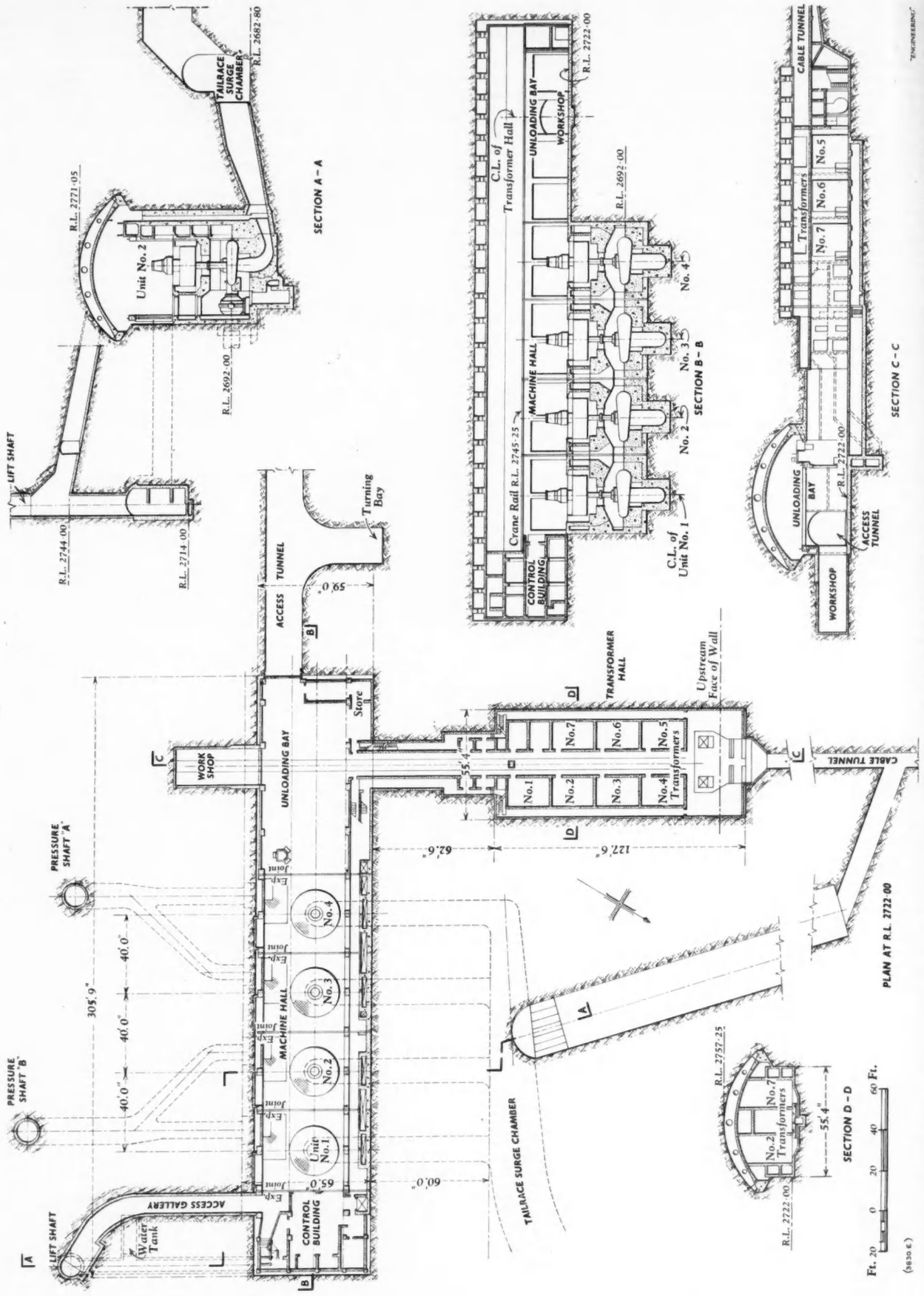


Fig. 14 Details of T1 underground power station. All heavy equipment will be brought through the access tunnel. When the station is operating the staff will use the lift as a means of access.

and transformers are carried in the stack of ducts shown on the downstream side of the section through the station, Fig. 14. Downstream of the ducts is the draft-tube gate slot, which by careful planning has been accommodated under the arch roof. The problem of providing stairs between floors without the need to make further excavation has been solved by designing the stairs as removable units occupying the spaces which must in any case be provided for installation and removal of the main valves.

TURBINES, GENERATORS AND TRANSFORMERS

The four turbines are being made by the English Electric Company, Limited; they are vertical Francis units, each with a nominal rating of 110,500 b.h.p. at a net head of 960 ft. and a speed of 375 r.p.m. The figure of 960 ft. for the head is a minimum, and it is hoped to run the machines normally under a head of 1,000 ft. Output will then be at 80 to 100 per cent. of the rated output, and the machines have therefore been specified to produce their peak efficiency under that condition.

The 80 MW 0·95 p.f. 12·5 kV generators, the output of which is 4,300 amps. at 10 per cent. overload, are being made in Sweden by A.S.E.A. The rotors each weigh 200 tons and are 13 ft. 11 in. in diameter, and 8 ft. 9 in. in pole length. The rotors must be built up at site, and the main parts of each rotor are a multi-arm spider, two pre-assembled laminated rings (each weighing 50 tons) and sixteen dovetailed poles. The octagonal stators are being made in four parts, each weighing 35 tons, which will be joined mechanically and electrically at site. The generators and exciters will be cooled by closed-cycle air circulation, and the air will be cooled through eight water coolers attached to the faces of the octagon frame.

Output from the generators is fed through the busbar ducts on 12·5 kV busbars of aluminium box section. Between the generator and the transformer halls there is an access way, and the ducts flank both sides of this passage. At the transformer end of the passage there are four 12·5 kV 4,300 amp. 1,000 MVA circuit breakers and associated air-break isolators.

There are seven single-phase 56 MVA transformers, made by A.C.E.C. of Belgium. One transformer is spare, and the others are arranged in two groups of three; each transformer has two 12·5 kV windings, and the output from two generators is fed to one group of transformers. The transmission voltage is 330 kV, and the high-voltage winding of each transformer is $330/\sqrt{3}$ kV.

The control room is at the access-lift end of the generator hall, and is one floor up from the main floor, thus giving a good view of the hall. A visitors' lounge and viewing gallery are next to the control room, and there are also a kitchen, mess, and an emergency bedroom. The control system has been designed for flexible handling of output under all circumstances, and for voltage control by synchronous condenser operation.

FUTURE DIVERSIONS

Other works in the Eucumbene-Tumut development, in various stages of planning and investigation, are: the Tooma-Tumut diversion and the Murrumbidgee-Eucumbene diversion; T2 power station ; Lob's Hole reservoir and T5 station; Cumberland reservoir and T6 station; and the Blowering reservoir and T7 station.

The two diversions will regulate the waters of the Upper Tooma and the Upper Murrumbidgee, permitting their waters either to be passed through T1, T2 and the Lower Tumut stations, or to be stored in the Adaminaby reservoir. The proposed Tooma dam is an earth and rock fill structure 220 ft. high and 1,180 ft. in crest length. The Tooma reservoir-Tumut pond tunnel is 47,300 ft. long, and has four shaft intakes throughout its length, which will divert the flow of various smaller streams in the area.

The T2 power station will be built underground and will contain four 70 MW sets developing a gross head of 935 ft. between the T2 diversion pond and the future Lob's Hole reservoir. This reservoir will have a storage capacity of 6,000 acre-feet and will control the supply of water to station T5, which will have an installed capacity of 180 MW. Below this is the Cumberland storage with a capacity of 36,000 acre-feet supplying the 230 MW T6 station. Finally will be the 800,000 acre-feet Blowering reservoir, the main purpose of which will be re-regulation of the Tumut flow for irrigation requirements, but which will also supply power to a small 60 MW station, T7.

This is the third of four articles on the Snowy Mountains Scheme. The first commenced on page 232 (August 24), the second on page 394 (September 28). The fourth, dealing with electrical distribution aspects, will be published shortly.

POWER POTENTIAL

HYDRO-ELECTRIC DEVELOPMENT IN THE U.S.S.R.

" Communism," Lenin is reported to have said, " is Socialism plus electrification." Throughout the ebb and flow of Soviet doctrine, this tenet—and perhaps this alone—has remained unassailed. The importance of electric power as a means to economic pre-eminence has always been accepted by the Russian authorities, and in their single-minded approach to this requirement lies a major threat to Western industrial supremacy. Soviet plans in the hydro-electric field have therefore some significance to engineers in other countries, and a first-hand account by a United Kingdom delegation discussing projects in hand and the construction methods employed may serve, not only to provide technical information, but to indicate the present position in the economic contest between West and East.

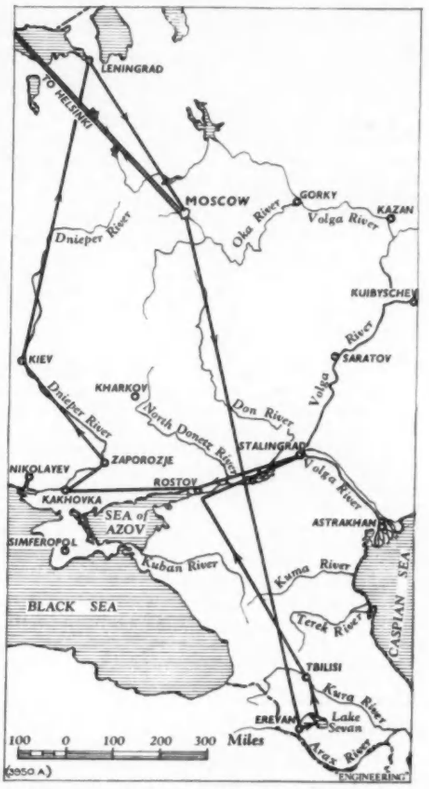
A British delegation of hydro-electric power engineers led by Sir John Hacking has recently visited the Soviet Union and carried out a tour lasting from October 10 to October 24 over the route shown in the accompanying map. He and two colleagues have described their visit to members of the Technical Press. They were anxious to make it clear, however, that though their notes had been checked against each other's, they had been dependent for their information largely on verbal communication through an interpreter. A full report is to be published by the delegation at a later date.

LAKE AS EXPENDABLE STORAGE

Projects.—Among the most interesting projects undertaken by the Soviet engineers is a scheme located in the south near Erevan. The level of Lake Sevan is to be lowered some 30 to 50 m. in the course of 50 years to provide an expendable storage of water for hydro-electric power supplies. As the level falls, the surface area will diminish (to one-sixth for the full 50 in. fall) so that evaporation will be reduced. In addition, the project will provide a considerable area of arable land since a section of the lake is comparatively shallow. There will be eight power stations, two of which are under construction and three planned; of three already operating one is 60 m. underground and may eventually be taken out of operation. The total output including this station will be 600 MW.

The team also visited a number of more orthodox projects some of which are now completed. These may be listed to indicate the scope of work already undertaken and to locate certain plants to which further reference will be made. The famous Dnieper dam and power station, destroyed during the war, has now been rebuilt and has a capacity of some 650 MW provided by 9 units of 72·5 MW each. A view of the power station interior appears at the top of the next page. The lowest station on the Dnieper River—at Black Sea level—is at Kakhovka, where the output is 312 MW from six 52 MW sets. This scheme which was building from 1950 to 1955 (though only 3½ years elapsed before the first sets came into operation) embodies a number of unusual construction features which will be discussed later. An illustration at the top of page 634 shows the dam spillway section at Kakhovka.

A dam 5 kilometres long is being built across the Volga at Stalingrad. This installation, which was begun in 1951 and should be finished in 1958, will have an output of 2,300 MW supplied by 22 Kaplan units. Other wide dams



In five years it is expected that hydro-electric development of the rivers Volga, Don and Dnieper in the Soviet Union will be complete. This map shows the route taken by a U.K. delegation. (*Kuibyschev is an alternative transliteration of Kuibishev.*)

across the Volga are one 7 km. wide and another near Gorky of 13 km. What will probably be the largest hydro-electric plant in the Soviet Union is under construction at Bratski (not shown) on the Angara River, a tributary of the Yenisei. Its output will be some 3,600 MW in 200 MW units, and it will transmit to the Urals.

RAISING THE CASPIAN

Other schemes include one on the Khrami River, a tributary of the Kura, where three sets of 112·8 MW will operate; one is already working, one under construction and one projected. At Krasnoyarsk a plant employing Francis 300 MW turbine units is in operation, and there is a station at Saratov of 1,000 MW. The team also saw parts of the Volga-Don Canal, which was opened in 1952 and were told that plans have been made to divert rivers into the Caspian Sea, which is 22 m. below sea level, in order to raise it by 2·5 m. to its original level. This will improve conditions in the river deltas, especially that of the Volga, increase flow through the Volga stations, replace irrigation water extracted from the river, and stop the gradual fall in the Caspian level.

The spillway section on the Kakhovka dam, the lowest on the River Dnieper, is faced with 8 cm. pre-cast concrete slabs keyed into position.

The Dnieper dam and power station destroyed during the war have now been rebuilt and give an output of 650 MW from nine 72·5 MW sets.

Construction Methods.—In building dams and other large installations, the Russians made full use of local materials and had built not only earth dams but also rock-filled dams and several other types, depending on the situation. They had little interest in arch dams since these were generally unsuitable for their conditions which involved in most cases wide rivers.

A dam at Khramskaya near Tbilisi had a very unusual facing employing 40 cm. of reinforced concrete and 8 mm. of stainless steel with U-shaped stainless-steel expansion joints. The need for stainless steel remained unexplained. Another facing, this time at Kakhovka, made use of 8 cm. thick pre-cast concrete slabs keyed into place; this can be seen in the illustration on the right at the top of the page. A further feature of the Kakhovka project is the use of shallow draught tubes, which serve to reduce the depth of foundation.

It was noted that 9 cm. corrugated bar was used for reinforcement and this was fusion welded together. No special methods were employed to cool concrete, but in winter aggregate, sand and water were heated to 28 deg. C. before mixing.

REMOTE CONTROL OF STATIONS

Transmission.—A notable feature of certain schemes is the use of remote control for power stations, which is carried out from a load-dispatching centre. This reduces the number of people required for plant operation and at one station on the Dnieper only six men per shift are needed. Already some transmission is carried out at 400 kV, but generally at 110 or 220 kV. There was one line at 200 kV direct current. The systems of European Russia are not totally interconnected but Leningrad and Moscow have recently been linked. A line for direct-current ransmission at $\pm$ 400 kV (effectively 800 kV) has been planned to join Moscow and the Donbas, so linking two previously unrelated systems.

Research.—The team also had opportunities to visit a number of research stations including establishments at Leningrad (where the principal station is situated), Moscow and Erevan. We shall discuss the administration of research later under a section dealing with the team's impressions, but to indicate the sort of research undertaken, we mention here some of the work in progress. In Moscow a large number of flow networks were under investigation by means of electrical analogy, and the team also saw an electron microscope, probably of Soviet manufacture, which was used for the examination of clays, silts and sands. A number of river models had been built, mainly with a horizontal scale of one-thousandth, including one of a complete barrage.

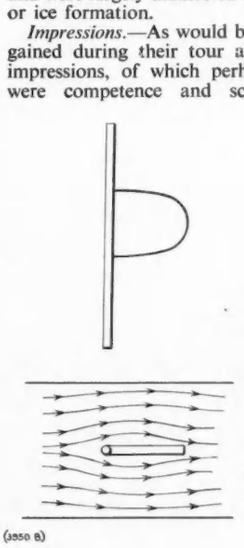
An illustration on this page shows a simple device for measuring low-velocity flow, which members of the team noticed and which was new at least to some of them. It comprises a shaft or pivot carrying a metal vane, which is placed in the liquid flow and allowed to find its equilibrium along the streamlines. A torque is applied, so displacing the vane against the flow, and the torque for a given angle measured. The instrument is calibrated so that flow can be read directly.

At the Erevan station work included water-hammer studies, the de-silting of intakes, the investigation of river beds and the study of hydraulic jump and other energy-dispersion problems. A test rig for investigating transit stresses in shafts when generators were put on load was seen.

Plans.—During the next five years, the Soviet authorities plan to finish the major schemes on the European rivers and to begin some of the still larger schemes in Siberia. This means that by 1960 the Volga, Don and Dnieper will be fully developed. The output from hydro-electric sources will be increased from 23×10^9 kWh per annum, (the figure for 1955), to 59×10^9 kWh in 1960. The capacity in 1955 represented only 13·6 per cent. of the total power supply from all sources and only 2 per cent. of the estimated hydro-electric potential of the Soviet Union. Hydro-electric supply in 1960 will comprise 18 per cent. of the total from all sources, including thermal and nuclear stations. It is thought that 80 per cent. of potential Soviet hydro-electric resources lies in Siberia from such rivers as the Ob, Angara and Yenisei.

The schemes are multi-purpose in that they are intended not only to provide power but also to assist in irrigation and navigation. The bulk of the power generated will be transmitted to European Russia, or rather, to the Urals, where immense industrialisation is in progress. The Russian engineers did not consider their hydro-electric plans to be affected by the development of nuclear power. Their stations had very high load factors, employing in effect pumped storage, and were largely unaffected by seasonal variation or ice formation.

Impressions.—As would be expected, the team gained during their tour a number of general impressions, of which perhaps the most vivid were competence and scale. The Russians seemed to be rather size conscious, preferring a larger unit where one or several smaller units might have been equally suitable. Often—witness the 13 kilometre Gorky dam—conditions demanded large installations, and size was after all a feature of the Soviet Union itself—a fact that may have helped to engender this attitude. Examples of large-scale work were the plan to divert rivers normally draining into the Arctic Ocean into the Caspian in order to raise its level, a station building at Kuibishev, which will have a capacity of some 2,100 MW (twenty 105 MW sets), the planned Bratski project, to have eventually an output of 3,600 MW (eighteen 200 MW sets), and the 300 MW Francis turbine units at Krasnoyarski. Excavation was also carried out on a large scale; earthworks at Stalingrad, for example, had amounted to some 143 million cub. m., and a 20 cub. m. dragline bucket was seen by the team. The size of the U.S.S.R. also meant that the scope and opportunities were immense.



(3550 a)

Soviet engineers regard simplicity as an important aim, as is evident from this simple low-velocity flow meter seen in a Moscow research laboratory.

But attention to detail was sometimes poor. Concrete was occasionally so honeycombed that it looked as if " the rats had got at it," and plastering up was a common practice. Nevertheless, marble floors and elaborate tiling were often observed in power-station buildings.

People engaged on construction work were well housed; housing was in fact of high standard and complete towns with theatres and concert halls had been built near the principal sites. Round-the-clock three-shift working was usual, and it seemed that the Government's aim to extend electrical capacity had entailed a ruthless devotion of resources to this end.

Mechanisation had been carried out to a considerable degree; at one site, with a peak working force of 15,300 men, it was claimed that there was 15 kW of power available per man. The use of remote control for power stations, however, may have meant that there was still a shortage of skilled labour, since such a system would have been expensive. There was reason to believe that capital charges were computed rather differently from the method used in Western countries, but the fact that the cost of power from the earlier stations (1 kopeck per unit at the Dnieper plant) was generally lower than from the more recent ones suggested that inflation is not confined to the capitalist system.

The manner in which research was organised was also revealing. The research itself was of a high standard, and, perhaps unexpectedly, the different establishments had considerable latitude and independence. Problems were co-ordinated only very loosely—to avoid duplication—and each laboratory tended to deal mainly with local problems, though each director would also carry out work in some specialised field for general use. Simplicity seems generally to be aimed at, as can be seen from the low-velocity flow measuring device already described. Results were published in abundance, but possibly in such quantity as to be barely manageable. But the overall impression was one of high competence, not only in research but also in design and execution. It is a warning and a spur.

ATOMIC REVIEW

Home Comforts

DIDO becomes critical—Tests on plutonium core—Routine check at Calder Hall—Permission granted for use of Winfrith site for atomic energy research station—Babcock and Wilcox make reactor vessel for Canadian nuclear power station—Hawker-Siddeley group adopts liquid-metal fuel reactor—Fifth group to undertake atomic power stations—Japanese atomic delegation in Britain—Instruments for Swiss reactor.

Heavy Water Research Reactor

Britain's first large heavy-water reactor DIDO, built for testing materials and the production of radioactive isotopes, began operating at the Atomic Energy Research Establishment, Harwell, on November 7. DIDO, previously known as E.443, has already been fully described in ENGINEERING (vol. 180, pages 235 and 836, 1955). It will develop about 10 MW of heat at full power, and its neutron flux will be some 10^{14} neutrons per sq. cm. per sec., making it the most powerful experimental reactor in Western Europe. The moderator is heavy water, from which the reactor's name is derived (D_2O), and highly enriched uranium is used as fuel. A model of DIDO appears in Fig. 1 and a sectional and labelled drawing on page 836 of vol. 180. Fig. 2 shows the reactor vessel, which was made by the A.P.V. Company, Limited, Manor Royal, Crawley, Sussex, and fabricated from 99·5 per cent. pure aluminium. DIDO will enable research to be carried out on materials, components and complete circuits for future reactors without the expense of prototype reactor construction. It is understood that a pressurised light-water loop at 2,000 lb. per sq. in. is being prepared by Babcock and Wilcox for insertion into DIDO.

Plutonium Core in Zephyr

Another research reactor at Harwell, ZEPHYR, has recently been the basis for an analysis of critical assembly and kinetics data obtained from an air-spaced plutonium core assembly (core II). A uranium-spaced plutonium core (core I) used in the first critical assembly of ZEPHYR was replaced by an air-spaced core. The decay of the neutron population after shut-down was analysed into five exponentials with periods corresponding to five groups of delayed neutrons. The group of period 1·1 sec. found with core I is assumed to be groups 4 and 5 of core II unresolved. With this identification there is no significant difference between the delayed neutron groups obtained with core I and core II. (A. R. Baker and D. D. McVicar. AERE RP/R. 1778.)

These experiments would seem to suggest that recent doubts concerning the usefulness of plutonium as a reactor fuel are unfounded, and that the difficulties, other than those related to handling, have been exaggerated.

Calder Hall Check

On November 6 the Calder Hall nuclear power station, which became critical on May 22 and has been supplying power to the national grid since October 17, was taken out of service for a routine check, so that any adjustments and corrections could be made. In addition, this overhaul may enable weaknesses in the first reactor to be remedied in the second, which is due to come into service next spring. It was the first of several checks which will take place during the 6 months commissioning period, and has been largely concerned with the lowest of the six fuel elements in each reactor fuel channel. These bear the weight of those above, and on this occasion four were examined. It is presumed that in the C.E.A. stations automatic loading and unloading devices will make shut-down for this sort of inspection unnecessary. The pressurised coolant circuit, which is reported to have been losing carbon dioxide at the rate of a ton a day when the station started up, had previously been examined and several leaks sealed. When the station was formally opened by the Queen on October 17, about 10 of the 28 MW generated at that time was supplied to the grid; since then output has been steadily increased up to four-fifths of full power and some 20 of the 35 MW generated has recently been transferred to the public system.

A.E.R.E. Dorset

Permission has now been granted to use the 688 acre site at Winfrith, near Dorchester, for an atomic energy research station. The station will be ancillary to the Harwell establishment, and may have a staff of 2,500.

Pressure Vessel for Canada

Babcock and Wilcox Limited announced last Friday that they had received in June an order for the construction of the reactor pressure vessel to be used in Canada's first nuclear power plant. NPD (Nuclear Power Demonstration), as the station is called, will have an output approaching 20 MW, will be cooled and moderated by pressurised heavy water and will use natural uranium as fuel. Reference has previously been made to the plant in ENGINEERING on September 28 (page 414) and October 19 (page 506). The vessel, which is currently under construction at the Renfrew works of Babcock and Wilcox, is approximately 12 ft. in diameter and 35 ft. high. It is designed for a pressure of 1,200 lb. per sq. in. and is 5 in. thick, increasing in places to 6½ in. It weighs 210 tons, of which 70 tons is in the head. This is bolted on since it must be capable of removal to permit full-way access into the vessel. The head contains numerous smaller openings, each with its own closure. Certain openings have been formed by pulling a metal ball through the shell by way of a small hole drilled in advance. The shoulders of the opening, which form on an outer ring die, are subsequently strengthened by welding. This method provides strong joints for the outside connections. To ensure that the vessel is of suitable quality and capable of withstanding the required cyclic load changes, Babcock and Wilcox have adopted the procedure of building a half-scale model and testing it to destruction. Extreme pressure tightness is necessary to prevent loss of valuable heavy water. The vessel has been built from a chromium (0·70 per cent. max.)-vanadium (0·10 per cent. max.)-molybdenum (0·28 per cent. max.) steel, Colvilles Ducol W30, which has a tensile strength range of 34 to 42 tons per sq. in. A drawing of a pressurised-water reactor prepared by Babcock and Wilcox is shown in Fig. 3; it is probably similar in most respects to the projected NPD plant. Babcock and Wilcox, who are members of the nuclear power group which also includes the English Electric Company and Taylor Woodrow, have in addition been carrying out considerable research for the gas-cooled stations to be built in Britain. We hope to describe this work in a subsequent issue.

Liquid Metal Fuel Reactor Adopted

A growing number of United Kingdom firms are entering the atomic power field, and it has recently been announced that the Hawker-Siddeley group is working on homogeneous reactor systems employing liquid-metal solutions or suspensions as fuels. It has been stated that the first stage in their experimental programme will be the formation of a metallurgical laboratory now nearing completion at Langley, Buckinghamshire. The studies to be carried out are likely to lead to the development of small reactors, not only for aircraft propulsion, but possibly too for mobile power plants, power generation in remote areas, mining, the production of process heat and marine applications.

Fifth Consortium

It has recently been reported that a fifth group of United Kingdom companies prepared to build complete atomic power stations is in process of formation. Sir Christopher Hinton is understood to be in favour of increasing the number of consortia, and the quantity of work likely to be available is confirmed by news of the new group. Its members are said to be International Combustion Limited, Crompton Parkinson, Limited, Richardsons, Westgarth and Company, Limited, and Trollope and Colls, Limited. It has also been reported that there is to be collaboration between Rolls-Royce Limited and the de Havilland Engine Company, both of which have been working on advanced small reactors, probably using closed-cycle gas-turbine

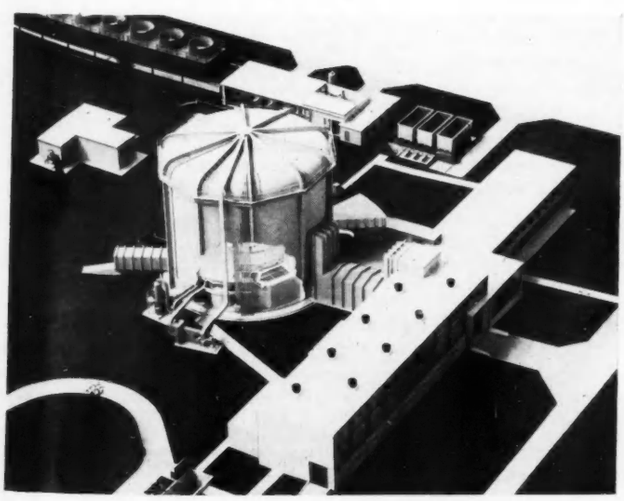


Fig. 1 (left) Model of Britain's high-power heavy-water materials-testing reactor, DIDO, which has recently become critical. In addition to producing radioactive isotopes it will serve to test materials, components and complete circuits by means of loops inserted in the pile. Design data for future reactors can thus be obtained without prototype construction.

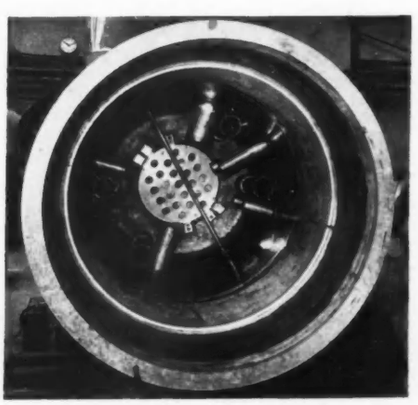


Fig. 2 (right) Reactor vessel for DIDO made by the A.P.V. Company, Limited. It was fabricated from 99·5 per cent. pure aluminium.

systems. Rolls-Royce, as stated in ENGINEERING on April 13 (vol. 181, page 220, 1956), are also co-operating with Vickers Nuclear Engineering Limited and the United Kingdom Foster Wheeler company.

Japanese Atomic Delegation

Delegates from a Japanese atomic energy survey group, headed by Dr. Ichiro Ishikawa, have recently been visiting factories and establishments in this country concerned with nuclear power. Among other premises visited are those of the G.E.C.—Simon-Carves Atomic Energy Group at Erith in Kent. The delegation is in Britain to carry out a preliminary survey of the possibility of using atomic power in Japan.

Instruments for Swiss Reactor

Isotope Developments Limited have secured a contract with Reaktor A.G. and Landis and Gyr S.A. of Switzerland to provide instruments for the control, safety and health monitoring of their materials testing reactor. The reactor is a high-power 20 MW (heat) heavy-water reactor being designed and built by Reaktor A.G. Isotope Developments have also contributed to the instrumentation of MERLIN.

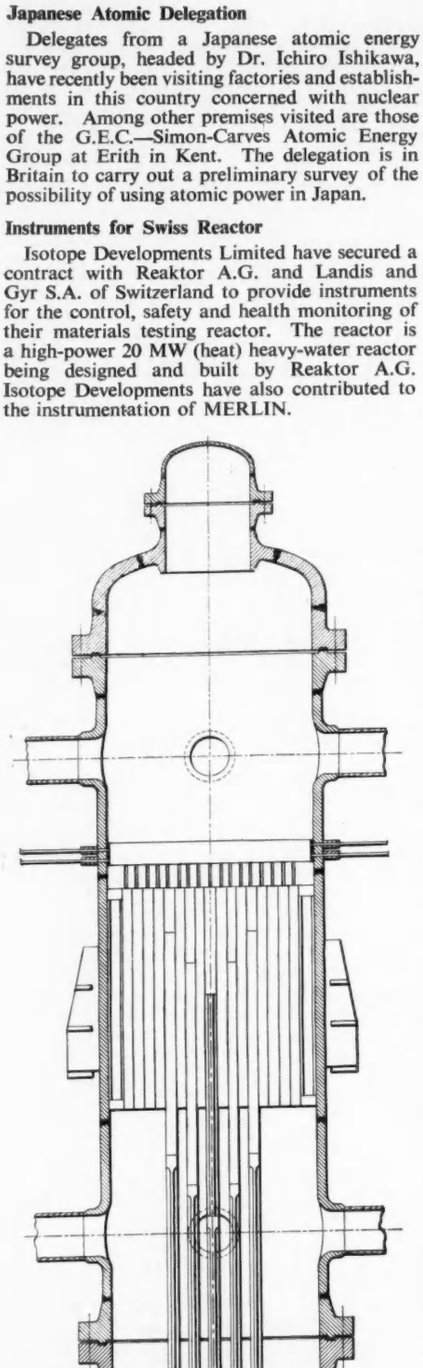


Fig. 3 Vessel for pressurised-water reactor. A similar vessel for the Canadian NPD station is being built by Babcock and Wilcox Limited.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

NOTTINGHAM
"Rolling Bearings" (with film), by C. S. Clarke. Nottingham Branch. East Midlands Electricity Board's offices, Smithy-row, Nottingham. Wed., Nov. 21, 7.30 p.m.

British Institute of Management

GLASGOW
"A Sales Manager Looks at Personnel Management," by A. F. C. Speyer. Joint lecture with the Glasgow and West of Scotland Management Association. St. Enoch Hotel, Glasgow. Tues., Nov. 20, 7.15 p.m.

British Institution of Radio Engineers

EDINBURGH
"Information Theory," by L. C. Stenning, Dr. P. Jones and P. Holroyd. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., Nov. 23, 7 p.m.

Building Centre

LONDON
Films on "Lead for Building." Wed., Nov. 21, 12.45 p.m.

Cement and Concrete Association

LONDON
"Design and Construction for the Prestressed Concrete Hangars at Helskinki," by Dr. F. W. Gifford and A. M. Janhunen. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Thurs., Nov. 22, 6 p.m.

Chadwick Public Lecture

LONDON
"The Health of the Worker," by Dr. P. A. Raffle. Royal Society of Health, 90 Buckingham Palace-road, S.W.1. Thurs., Nov. 22, 5.30 p.m.

Chemical Society

ABERDEEN
"Physical Properties of High Polymers in Relation to Their Chemical Structures," by Professor G. Gee. Aberdeen Branch. Chemistry Department, The University, Old Aberdeen. Fri., Nov. 23, 7 p.m.
EDINBURGH
"Polymerisation in Heterogenous Systems," by Professor C. E. H. Bawn. Edinburgh Branch. North British Station Hotel, Edinburgh. Thurs., Nov. 22, 7.30 p.m.
SOUTHAMPTON
"Some Aspects of the Organic Chemistry of Phosphorus," by Professor H. N. Rydon. Southampton Branch. Chemistry Department, The University, Southampton. Fri., Nov. 23, 5 p.m.

Combustion Engineering Association

OLDBURY
One-Day Conference. "Smokeless Operation of Boilers and Furnaces on Solid Fuel," by C. H. G. Hayward, at 10.30 a.m. and "Smokeless Operation of Boilers and Furnaces on Liquid Fuel," by W. H. Adams, at 2.30 p.m. Talbot Hotel, Oldbury. Wed., Nov. 21.

Illuminating Engineering Society

BIRMINGHAM
"Modern Applications of Plastics to Lighting Fittings," by P. H. Collins. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Nov. 23, 6 p.m.
CHELTENHAM
"Road Vehicle Lighting," by K. J. Jones. Gloucester and Cheltenham Centre. Fleece Hotel, High-street, Cheltenham. Tues., Nov. 20, 6.30 p.m.

Incorporated Plant Engineers

ROCHESTER
"Operation and Maintenance of Fuel Economisers," by H. J. Gardner. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Nov. 21, 7 p.m.

Institute of British Foundrymen

IPSWICH
"Modern Methods of Patternmaking, with Particular Reference to Pressure Cast Pattern Plates," by B. N. S. Perry. East Anglian Section. Public Library, Old Foundry-road entrance, Ipswich. Tues., Nov. 20, 7.30 p.m.
SOUTHAMPTON
Discussion on "Shell Moulding" (with film). Southampton Section. Technical College, St. Mary-street, Southampton. Wed., Nov. 21, 7.30 p.m.

Institute of General Managers

LONDON
"Automation in the Office," by Geoffrey Mills. Charing Cross Hotel, Strand, W.C.2. Tues., Nov. 20, 7 p.m.*

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"Boiler Water Treatment," by F. C. V. Holmes. Southern Joint Branch. Southampton Technical College, St. Mary-street, Southampton. Tues., Nov. 20, 7.30 p.m.

Institute of Marine Engineers

BIRKENHEAD
"Control of Steam Temperature in Marine Water-Tube Boilers," by E. G. Hutchings. Junior Lecture. Merseyside and North Western Section. Birkenhead Technical College, Birkenhead. Fri., Nov. 23, 7.15 p.m.
BIRMINGHAM
"Nuclear Engineering," by J. A. Kendall. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Nov. 22, 7 p.m.*
CARDIFF
"Carriage of Edible Oil and Similar Bulk Cargoes," by J. Wormald. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Nov. 20, 7.15 p.m.
KINGSTON-UPON-HULL
"Some Experiences on Vessels Equipped with Two-Stroke Harland and Wolff Opposed-Piston Diesel Engines Using Boiler Oil," by A. G. Arnold, presented by W. H. Falconer. Kingston-upon-Hull and East Midlands Section. Royal Station Hotel, Kingston-upon-Hull. Thurs., Nov. 22, 7.30 p.m.

Institute of Metals

BIRMINGHAM
"Fatigue," by Dr. N. Thompson. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Nov. 22, 6.30 p.m.
SHEFFIELD
"Automation," by Dr. H. D. Turner. Sheffield Local Section. The University, St. George's-square, Sheffield. Mon., Nov. 19, 7.30 p.m.

Institute of Road Transport Engineers

DURHAM
Open Meeting. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., Nov. 27, 7 p.m.

Institution of British Agricultural Engineers

BIRMINGHAM
"Modern Equipment for Milk Production," by H. S. Hall. West Midlands Centre. At works of Wolseley Engineering Ltd., Witton, Birmingham. Mon., Nov. 26, 7.30 p.m.

Institution of Chemical Engineers

LEEDS
"Non-Newtonian Fluids," by E. G. Richardson. North Western Branch. The University, Leeds. Wed., Nov. 21, 7 p.m.

Institution of Civil Engineers

LONDON
"Allt-na-Lairige Prestressed-Concrete Dam," by J. A. Banks. Tues., Nov. 20, 5.30 p.m.*
LIVERPOOL
Chairman's Address by Professor J. A. L. Matheson. North Western Association. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Nov. 21, 6 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Data Processing Equipment for Experimental Work: A Review of Techniques and Methods," opened by Dr. W. V. Wilkes. Measurement and Control Section. Tues., Nov. 20, 5.30 p.m.*
Discussion on "Aluminium Conductor Cables," opened by G. F. Peirson. Supply Section. Wed., Nov. 21, 5.30 p.m.*
Discussion on "The Presentation and Demonstration of the Theory of Semi-Conductors to Students of Electrical Engineering," opened by P. Godfrey. Education Discussion Circle. Thurs., Nov. 22, 6 p.m.*
CHELMSFORD
"Manufacture of Electric Cables," by J. D. Navey. London Graduate and Student Section. Public Library, Chelmsford. Tues., Nov. 20, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.1. (SLOane 5255.)
Chadwick Trust, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Dury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of General Managers. Apply to C. J. Hatter, 38 Chalkhill-rd., Wembley Park, Middlesex. (ARNold 8863.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. (SLOane 0061.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield 1. (Sheffield 24071.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

CHESTER
"Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33-kV and Above," by A. Morris Thomas and D. F. Oakeshott. Mersey and North Wales Centre. Town Hall, Chester. Mon., Nov. 19, 6.30 p.m.
LEEDS
Discussion on "The Influence of Maintenance Requirements on the Design of Industrial Electrical Equipment," opened by H. C. Fox. North Midland Centre. Offices of the Yorkshire Electricity Division, 1 Whitehall-road, Leeds. Tues., Nov. 20, 6.30 p.m.
LOUGHBOROUGH
"Ultrasonics in Industry" (with film), by C. F. Brocklesby. East Midland Centre. Loughborough College, Loughborough. Tues., Nov. 20, 6.30 p.m.

Institution of Engineering Designers

LONDON
"Automation and the Designer," by Frank G. Woollard. Thurs., Nov. 22, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Recent Work in the Lithgow Water Tunnel at the N.P.L.," by A. Silverleaf and L. W. Berry. Tues., Nov. 20, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LEEDS
"High-Pressure Hot Water," by N. Fincher. Yorkshire Branch. Griffin Hotel, Leeds. Wed., Nov. 21, 7.30 p.m.
LIVERPOOL
"Pipe Sizing Extraordinary," by T. H. F. Holman. Liverpool Branch. College of Building, Clarence-street, Liverpool. Tues., Nov. 20, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"The Training of a Locomotive Engineer," by Sir Ronald Nesbitt Hawes; "Engineering Training in the Main Workshops of British Railways," by G. F. Parker; and "Recruitment and Training of Officers for the Mechanical Engineering and Transportation (Power) Departments of Indian Government Railways," by P. G. C. Peyton. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Nov. 21, 5.30 p.m.*

Institution of Mechanical Engineers

BRISTOL
"Power Station Auxiliary Plant," by G. F. Kennedy and F. J. Hutchinson. Western Branch. University Engineering Laboratories, University-walk, Bristol. Wed., Nov. 21, 7 p.m.*
CAMBRIDGE
Discussion on "Technical Education." Eastern Branch. Cambridgeshire Technical College, Cambridge. Tues., Nov. 20, 6.30 p.m.
GLASGOW
"Construction and Use of Earth Moving Vehicles," by William Rankin. Scottish A.D. Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Nov. 19, 7.30 p.m.
LEEDS
"Rubber Springs for Vehicle Suspension," by A. E. Moulton and P. W. Turner. North Eastern A.D. Centre. Chemistry Lecture Theatre, The University, Leeds. Wed., Nov. 21, 7.30 p.m.
LEICESTER
"Experiments on the Deflections and Vibrations of Radial-Drilling Machines under Test and Working Conditions," by Dr. D. F. Galloway. East Midland Branch. College of Technology and Commerce, Leicester. Wed., Nov. 21, 7.15 p.m.
LUTON
Five U.S. papers on "Research in Automobile Stability and Control." Luton A.D. Centre. George Hotel, Luton. Mon., Nov. 19, 7 p.m.
MAIDSTONE
"Financial Management Problems of the Smaller Firms," by J. B. Connolly. Southern Branch. Star Hotel, Maidstone. Wed., Nov. 21, 7 p.m.

Institution of Production Engineers

BIRMINGHAM
"Use of Isotopes in Industry," by Dr. H. Seligman. Birmingham Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Nov. 21, 7 p.m.
CARDIFF
"Training of Production Engineers," by Dr. V. A. J. Chapman. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Nov. 23, 7 p.m.
NORWICH
"Aspects of Practical Training for Sandwich Courses," by V. Crowther. Northwich Section. Assembly House, Norwich. Wed., Nov. 21, 7.30 p.m.
SOUTHAMPTON
"Production of Agricultural Implements," by D. M. MacDonell. Southern Section. Polygon Hotel, Southampton. Thurs., Nov. 22, 7.15 p.m.

Institution of Structural Engineers

LONDON
"Design and Construction of the Prestressed Concrete Hangars at Helsinki Airport, Finland," by Dr. F. W. Gifford and Matti Janhunen. Thurs., Nov. 22, 6 p.m.
BIRMINGHAM
"Design, Manufacture and Full-Scale Test on Formed Structural Sections," by E. Griffin and Dr. J. M. Harvey. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., Nov. 23, 6 p.m.
LEEDS
"Examples of Drift Tunnelling and Prestressing in the Coal Industry," by H. C. Griffiths. Yorkshire Branch. Offices of the Yorkshire Electricity Division, 1 Whitehall-road, Leeds. Wed., Nov. 21, 6.30 p.m.

Institution of Water Engineers

LONDON
Symposium on "Frozen Plumbing." South Eastern Section. Institution of Civil Engineers, Great George-street, S.W.1. Mon., Nov. 19, 2.30 p.m.

Iron and Steel Institute

LONDON
Autumn General Meeting. Wed., Nov. 21, 10.45 a.m. and 2.15 p.m.; and Thurs., Nov. 22, 10 a.m. and 2.15 p.m.

Junior Institution of Engineers

LONDON
"Production of Flat Surfaces on Lapmaster Flat Lapping Machines," by L. P. Hulin. Fri., Nov. 23, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Computers in Industry," by B. Pollard. Engineers' Club, Albert-square, Manchester. Fri., Nov. 23, 6.45 p.m.

Royal Aeronautical Society

LONDON
British Commonwealth and Empire Lecture on "Aeronautical Development in Australia and Its Potential Value to the British Commonwealth," by L. P. Coombes. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Nov. 22, 6 p.m.*

Royal Statistical Society

LONDON
"The Replacement Cost of Fixed Assets in British Manufacturing Industry in 1955," by Dr. T. Barna. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Nov. 21, 5.15 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Aspects of Ceramics in Nuclear Energy," by Dr. P. Murray. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Nov. 20, 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Automation," by Dr. H. D. Turner. Engineering Lecture Theatre, The University, St. Georges-square, Sheffield, 1. Mon., Nov. 19, 7.30 p.m.

Society of Instrument Technology

MANCHESTER
"Control of Distillation Columns," by J. W. Broadhurst. Manchester Section. College of Technology, Manchester. Tues., Nov. 20, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Instrumentation in the Steel Industry," by J. D. May. Newcastle Section. King's College, Stephenson Building, Newcastle-upon-Tyne. Wed., Nov. 21, 7 p.m.

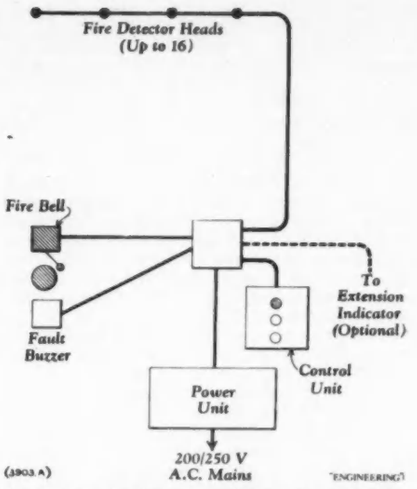


Fig. 1 The simplest form of Pyrene fire-detecting installation. Up to 16 fire-detector heads are connected to one control unit, providing local warning of fire or fault conditions.

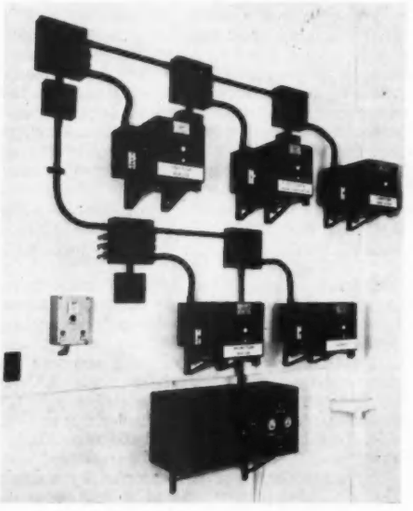


Fig. 2 A more complex system, employing 70 detector heads, is installed at the works of Redler Conveyors, Limited. Seen here are the five control units and single power unit and, on the left, the transmitter unit which relays fire and fault signals to a receiver unit in the fire brigade watchroom.

FIRE DETECTION BASED ON RATE OF TEMPERATURE RISE

WARNINGS RELAYED TO FIRE BRIGADE

In the rate-of-rise fire detecting system recently developed by the Pyrene Company, Limited, 9, Grosvenor-gardens, London, S.W.1, instant warning is given upon an abnormal rise of temperature. To do this, fire-detector heads are suitably placed throughout a building or industrial site. Each group of up to 16 heads is connected to a control unit equipped with signal lamps indicating normal operation as well as warning of fire or faults in the circuit. The warning system may be relayed onwards by means of transmitting and receiving units to one or a number of fire report centres, and to the public fire brigade through a G.P.O. telephone line.

The operation of this system in its simplest form is illustrated in the diagram shown in Fig. 1. This installation comprises up to 16 fire-detector heads, one power unit, one control unit, an extension indicator (optional), visible fire and fault signals and audible fire and fault warnings. The power unit allows for extension of the system since it is capable of operating a maximum of five control units and 80 detector heads.

FIRE DETECTOR HEADS

The detector head (Fig. 3), which is electrical in operation, consists of two separate windings of tungsten wire and a fusible link, supported on a former made of refractory material. One winding is fully exposed to the atmosphere; the other winding is shielded. The assembled former is rigidly mounted on a steel base, the windings being protected by a metal grille. When a detector head is subjected to a sudden rise of temperature the electric resistance of the exposed wire rises above that of the shielded wire. The resultant reduction in current in the exposed wire unbalances a polarised relay which actuates the fire alarm circuit. The system is self-adjusting under average conditions of temperature change, and although the detector is highly sensitive to sudden rises of temperature, it may readily be arranged to meet exceptional conditions. Provision is made in each detector head for a very gradual increase in ambient temperature. This takes the form of an independent fusible spring-link which unbalances the polarised relay at 150 deg. F. or other pre-determined temperatures.

CONTROL UNIT

The control unit is connected with up to 16 detector heads in series. It contains relays whereby audible and visible signals are automatically registered. On the front of the cabinet are mounted three indicator lamps—red to give warning of fire (in conjunction with a separate electric alarm bell), green which lights continuously while the system is normal, amber to register a fault in the circuit (in conjunction with a separate buzzer). A test and re-set switch fitted to the cabinet is operated to restore balanced conditions after a fire or fault has been signalled. Electrical connections to the detector heads, the audible warning devices, the power unit, and so on, are made at a junction box. The control unit is mounted on a wall together with the power unit and the other equipment, in such a

position as to be accessible and easily observed, yet safe from vibration or physical shock. If it is desired that the visible warnings should be extended to another part of the building, connections may be made from the control unit to an extension indicator which houses a duplicate set of three indicator lamps.

POWER SUPPLY

All Pyrene fire detecting systems are designed to operate from a 200/250 volt alternating-current supply. Their functioning, however, is independent of mains supply failure since the power unit incorporates a storage battery continuously maintained by a trickle charger. Should the mains input be interrupted, the cells carry the load of a complete circuit for a period of time dependent on the capacity of the battery and the number of control units being supplied. Under normal operating conditions the system will continue to function for as long as 60 hours after breakdown of the mains supply.

The complete circuit operates on a nominal 12 volt direct-current supply and the maximum current requirement is of the order of 0·3 amperes.

Up to five control units may be energised by one power unit, which houses the storage battery and the trickle charger, suitably calibrated to ensure that the battery is charged at the correct rate. This unit incorporates (1) a fault indicator which, in the event of an electrical supply failure, automatically energises a fault buzzer. This may be isolated when the "Alarms off" switch is raised; (2) a blue indicator lamp to show that local alarms have been switched off; (3) a selector switch to be set according to the number of control units (up to five) in operation; (4) a voltmeter to register the voltage of the complete system; (5) an ammeter to indicate the current flowing in the circuit; (6) a cartridge-type fuse; (7) a red indicator lamp which is illuminated continuously while the mains supply is available to the trickle charger.

RE-TRANSMISSION EQUIPMENT

Where a large area is involved necessitating a number of distant fire report centres, fire alarm signals may be relayed to them by installing re-transmission equipment.

The control unit or units in any one area are connected to a main transmitter unit. This is a metal box fitted with three switches, one for fault-alarm testing and one for fire-alarm testing, while the third is an isolating switch to check that indication of line failures will be registered.

The transmitter unit is connected by a single telephone line (two wires) to a receiver unit. This unit is fitted with a red and an amber lamp as well as test buttons and test switches, and provision for wiring to a common fire bell and fault buzzer. This unit therefore serves as a repeater of the audible and visible signals which are made at the area control unit.

Whatever the layout of the fire-detecting installation itself, re-transmission signal equipment may be extended through a G.P.O. telephone line to the nearest public fire brigade station. Thus a composite fire-detecting system is capable of providing fire or fault warning simultaneously (*a*) in the fire risk area itself, (*b*) at the company's report centre, and (*c*) at the public fire brigade as well. Such a system embodies a transmitting unit, a telephone line and a receiver unit serving each separate area installation; the receiver units are grouped together at the report centre or works fire station and suitably identified from each other.

An important advantage of all Pyrene fire-detecting systems and re-transmission signal equipment is the provision of automatic warning should any part of the system fail. This takes the form of visible and audible alarms which operate instantly whenever a fault occurs in the site installation, in the telephone lines, or when the mains supply fails. Every system is thus completely supervised electrically.

A typical installation, in this case at the Stroud works of Redler Conveyors, Limited, is shown in Fig. 2. This installation has an extension line to the Stroud station of the County Fire Service, and embodies five separate circuits and five control units which, together with the visible and audible alarms, power unit and transmitter unit are mounted in compact form on a board fixed to the wall of the inquiry office. In all, 70 fire detector heads are connected to the five control units. In the event of fire being detected by any one of the heads the warning is instantly given by a red light on the appropriate control unit and an alarm bell outside the building, and is simultaneously transmitted to the fire station.

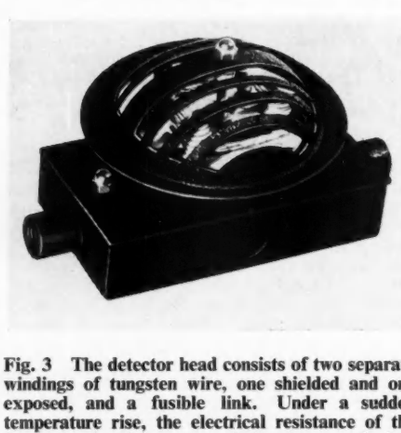


Fig. 3 The detector head consists of two separate windings of tungsten wire, one shielded and one exposed, and a fusible link. Under a sudden temperature rise, the electrical resistance of the exposed wire increases, unbalancing a polarised relay actuating the alarm circuit. Should the temperature build up gradually to over 150 deg. F., the fusible link actuates the relay.

FOUNDRY MECHANISATION WITH FUME REMOVAL

In order to increase the output of cylinder blocks for motor vehicles, that section of the Farington iron and steel foundry of Leyland Motors, Limited, Leyland, Lancashire, devoted to the production of these components, has been reorganised and mechanised. The plant affected is the green-sand moulding and casting shop which produces many hundreds of blocks weekly for British and foreign manufacturers of engines, such as the Jaguar, Albion, International Har-vester and Valmet (Finland). It is entirely separate from the foundry engaged in supplying castings for the firm's Diesel engines.

The new installation includes automatic machines and power-driven conveyors and also roller conveyors extending nearly 500 ft. in length. In addition to an increase of 100 per cent. in the output of green-sand castings, the benefits accruing from the new plant comprise improved working conditions for the foundrymen, as fumes previously released in the foundry are collected and dispersed by an overhead canopy extractor unit and a cooling tunnel.

Cast-iron pouring station, showing the fume-extraction canopy over the power conveyor, in the newly-mechanised motor-vehicle cylinder-block casting section of the Farington foundry of Leyland Motors Ltd.

The new moulding line commences with an automatic moulding machine which produces the lower mould or drag and a similar machine a little further along the line producing the upper mould or cope. Each machine is controlled by an electric timing device which regulates the intervals between operations once the machine has been set in motion. A moulding box is placed on the table of each moulding machine and sand is fed into the box from an overhead hopper, the doors of which are operated by a pedal. When the operator presses the starting button, an arm carrying the squeeze head swings in over the table and the machine is jolted for a pre-set time to settle the sand. The table then rises against the squeeze head to compress the sand in the moulding box, the jolting being continued meanwhile to achieve the maximum mould consistency. When this operation is completed the table sinks to its original level, the squeeze head swings away and four pins engage the underside of the moulding box to strip the mould clear of the pattern.

The moulding box is then placed by an overhead crane on the power-driven conveyor which is joined at this point by a pendulum-type conveyor carrying cores. These are placed in position and the assembly of the mould finally completed. The power conveyor is driven by an electric motor and its speed is infinitely variable and can be controlled at any rate up to a maximum of 5 ft. per minute.

The finished moulds continue their travel to the pouring station where an electrically-operated overhead monorail has been installed to carry the ladle in which molten iron is transferred from the cupola. It is at this point that the need for fume extraction commences, and an overhead fume canopy 60 ft. in length which leaves the working space unobstructed withdraws the fumes by fan suction. Part of this canopy is seen in the accompanying illustration. On leaving the pouring station the castings enter the fume tunnel in which any fumes given off during the cooling period are collected and discharged to the outside atmosphere. When the moulding boxes emerge from the tunnel the cope is lifted off and a shake-out machine removes the sand, which is returned to an underground pit for reclamation. The cope then travels down a roller conveyor to the point at which it started its journey.

The drag carrying the casting travels on a little further to a point at which the casting is transferred to another conveyor for transit to the dressing shop. The drag is then removed from the line by a pneumatic pusher on to a shake-out machine for sand reclamation. Thence it returns to its starting point by roller conveyor.

In Parliament

A BUSY SESSION ENDED

On Monday of last week, the first session of the present Parliament was brought to a close. From a technological and commercial point of view, the session, which began on June 7 last year, has been one of great activity and has witnessed the passing of a number of important Bills.

Among the measures to which approval was given may be mentioned the Act to provide for the registration of restrictive trading agreements and their judicial examination by a special court, and to prohibit the collective enforcement of resale price conditions. This Act is intended to stimulate competitive enterprise. Other enactments covered the introduction of new arrangements for financing agricultural research and for amending the constitution of the Department of Scientific and Industrial Research.

Legislation was also passed to abate the evils of air pollution, and to provide for the health and welfare of persons employed in agriculture and forestry. The Government announced a five-year plan for extending technical education, and the law relating to education in Scotland was amended. They were much concerned with traffic on the roads, in which connection legislation was passed to improve the regulation of road traffic and to promote additional safety requirements.

Almost the last business of the session was to announce that six new Acts had received the royal assent. Among these were the Copyright Act, 1956, and the South of Scotland Electricity Order Confirmation Act, 1956.

AND A NEW ONE BEGUN

At 11 o'clock on the following morning, H.M. The Queen opened the new session. In accordance with custom, the intentions of the Government and the main issues to be incorporated in their programme for the coming months were briefly outlined in the Queen's Speech, which was presented to the two Houses of Parliament.

Apart from a number of matters of mainly political or legal interest, Her Majesty said that her ministers would continue to seek the collaboration of employers and workpeople in combining full employment, rising production and stable prices. They were convinced that the wisdom and experience of the nation would be a powerful aid to them in that task.

It would be the aim of the Government to fortify the balance of payments and to extend oversea markets for British goods and services. While fostering the traditional and established Commonwealth preferential system, ministers attached great importance to increasing and strengthening economic co-operation in Europe. To that end, the Government were examining possible methods for creating in Europe an area within which restrictions on the free exchange of goods, other than foodstuffs, would be progressively removed. Consistent with international obligations, legislation would be introduced to allow countervailing and anti-dumping duties to be imposed on imported goods.

A measure would be laid before Parliament to replace the existing emergency powers in respect of hire-purchase and hiring agreements and to regulate borrowing by hire-purchase finance companies. There would be a Bill to give effect to proposals arising from the recent comprehensive review of the financial and economic position and prospects of the British Transport Commission. Another Bill would provide for the re-organisation of the electricity-supply industry in England and Wales.

Among other measures envisaged were the provision of a remedy for damage caused by subsidence due to coalmining; the promotion of conditions which would enable the agricultural industry to maintain its progress and increase its efficiency; and the granting of continued financial assistance for certain sections of the fishing industry and for the modernising of their fishing fleets.

The Government, Her Majesty said, were resolved to maintain progress in improving social and working conditions, and, in due course, there would be a Bill to amend the law about the closing hours of shops and related matters. Her ministers would continue to give a high place in the building programme to the erection of new schools. They would also press on with their plans for expanding the facilities for technical education.

In accordance with precedent, a considerable amount of time was spent during the first days of the new session on the Loyal Address in reply to Her Majesty's speech.

RIGHT VIEWS ON AUTOMATION

An interesting and informative debate on automation took place in the House of Lords during one of the concluding sittings of the old session. It was introduced by Lord Macdonald of Gwaenysgor (Labour), who called attention to the report of the Department of Scientific and Industrial Research on Automation and inquired as to what action the Government proposed to take thereon.

The question had been before the country for many months and there had been many conferences to discuss the problems involved. In his view, these discussions had done much to remove the confusion and doubts felt by workpeople, and had given them a much more accurate conception of what automation would mean to the life of the nation. Indeed, it was vital that people in industry should have the right attitude to changed methods.

It was clear that automation would enable industry to give greater outputs. Those responsible for its introduction, at any rate in the early stages, were the managements. They were carrying on their businesses in competition with other people and they had a very difficult task to perform in deciding when, and at what rate, they would introduce automatic methods. Whether to disclose a top secret which they wanted to keep from their competitors was not an easy matter to decide. At the same time, they should realise that, if they told their workers in the right way and at the right time, the introduction of automation would be greatly helped.

GOVERNMENT AID DESIRABLE

Then there was the part the Government could play. The Government could not just stand at one side and forget the financial aspects of automation. Money spent for defence purposes should not be begrudged, but it might be possible to arrange that some defence expenditure could be used to assist the introduction of automation. Personally, Lord Macdonald said, he would not suggest a subsidy for private enterprise. All the same, the Government should examine the financing of those firms which were unable to introduce automation at the rate the Government thought necessary in order that the nation might hold its own in the race for trade and exports.

On the labour side of industry, it was felt that there would be difficulties to overcome and burdens to be borne during the transitional period but it should be possible to hammer out a scheme to ensure that no section of the community had to bear more than its share. The Government should take the steps necessary to see that skilled labour was available right through industry. Research, also, was most important.

Lord Bennett of Edgbaston (Conservative) agreed that there had been a distinct change during the past few months in the way automation was being approached. The earlier hysteria seemed to have died. "Automation" was an awkward word. Like many such words that came from America, it tried to cram into itself too much meaning. It should be realised that automation was merely a new word and not a new technique. People in industry were used to automation and regarded it as the extended adoption of methods that had been in use ever since industry began. Even electronics, of which people spoke with bated breath, had been known in industry for a generation.

Compensation for Lost Jobs

The view was taken by Viscount Hall (Labour) that it would prove to be industrial suicide for this country if it were not to make full use of these techniques. Lord Crook (Labour) reminded the House that he was one of the only two ex-trade union officials who were members and pointed out that workers needed to understand that their fears about mechanisation and rationalisation were not fears that need be justified about automation, either to-day or in the future, if there were good industrial relations.

Men must be told what compensation would be theirs, if, in fact, they lost their employment owing to re-organisation. Compensation to workers who had given their lives to jobs was as fair and reasonable a charge on industry as was that paid to directors when they were dispossessed of their jobs. Lord Greenhill (Labour) stressed the importance of finding the necessary numbers of skilled men, and Lord Chorley (Labour) expressed his concern at the progress being made in Russia. The feeling that Russians were not capable of being competent technicians was a very dangerous one.

Technical Training the Key

In his reply to the debate, Viscount Hailsham, the First Lord of the Admiralty, said that, just as iron and steam had largely given place to steel, oil, electric power and aircraft, so that age appeared to be being succeeded by one of electronics, plastics and nuclear power. Like its predecessors, the development of automation would lead, on balance, to an increase in wealth and, quite directly, therefore, to more employment, improved standards of living, and the development of higher technical skills.

What automation demanded, if hardships were to be avoided, was clear-sighted planning by managements, in direct consultation with the workpeople. The crux of the problem was to look ahead as far as possible, in order to ascertain the market for the product. A good employer would try to calculate his labour requirements on a longer term basis than hitherto. Above all, he would treat his employees as human beings with a real stake in the industry at least as great as his own shareholdings.

In addition to the machine and process operators, who, in the main, could be trained by the industry concerned without much difficulty, automation required a new cadre of maintenance men and technicians, together with increased numbers of highly-specialised technologists and managers. What was needed was not something different, but increased numbers of the best that the country already had.

Industry, the Services and even the technical colleges, were already providing apprentices to become technicians, maintenance men, fitters, turners, tool setters and other craftsmen, on a scale undreamt of before the recent war. There was an increasing need for more men of this kind, and for new and modified types of training. Examinations were of the greatest importance in this particular field, as a new qualification encouraged students to embark on a new type of course, whereas, in the absence of a recognised certificate, students were unlikely to enrol at all.

The challenge of automation was among the many stimulating and exciting potentialities of our time and as such it must be welcomed by unions, managements and Governments.

Heavy Electrical Plant

Mr. C. Osborne (Conservative) asked the President of the Board of Trade for information respecting the request by manufacturers of heavy electrical plant that he should not publish parts of the Monopolies Commission's report on that industry. Mr. Derek Walker-Smith, the Parliamentary Secretary to the Board, urged that the publication of the report should be awaited. Inferences should not be drawn about its contents from statements which had been published in the Press.

THE HUMAN ELEMENT

Will the unions accept less this year?—No pensions yet for dockers—Negotiation without coercion—The Russian version of unions—Wages set for whole industries—Degrees for managers.

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Busmen's 3 Per Cent.

The Industrial Disputes Tribunal has awarded an increase of 3 per cent. to municipal bus workers. The formal amount is 5*s.* a week. Beyond this decision lies the tactical position which the unions will take up on behalf of provincial bus workers, London Transport workers and railwaymen. This 5s. rise compares with one of 11*s.*, in November, 1955. There is thus a noticeable scaling down in the award.

The impression is indeed growing that the unions will be content in general with smaller increases than they won last year. It is no more than an impression, however, at this stage. Some of the more militry unions may decide even at the last moment that their tradition of militancy prevents them from retreating too far from their initial claim. At the moment their key assault forces have dug themselves in on the 10 per cent. line. The critical tests are still engineering and the railways. The coalminers continue to press for the abolition of the bonus shift disqualification rather than for a general rise in pay and the signs at the moment are that they will get what they are after.

Between the A.E.U. and the N.U.R. the attitude of the latter is rather the more critical. Signs are not lacking that the engineering workers will accept a compromise if the situation is handled with tact. The position of the railway unions is rather more obscure. The decision of the Government to bring in legislation to authorise the Ministry of Transport to advance £330 million in loans to the railways (on terms discussed in a note on page 615) makes any increase in pay from now on in the case of railwaymen a form of direct subsidy from the taxpayer.

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Higher Guaranteed Wage for Dockers

Agreement was reached last week between the Dockers' unions and the National Association of Port Employers whereby the guaranteed weekly wage for dock workers is raised by 16*s.* 6*d.* to £6 1*s.* 0*d.* The unions' request was prompted by a fall in port traffic brought about by import cuts in Australia and New Zealand and the Suez Canal blockage. Between 6,000 and 7,000 men out of 80,000 are surplus to requirements. The London Dock Labour Board have suspended recruitment. The increase in the guaranteed minimum pay affects only those workers who present themselves for work at recognised times but whose earnings are kept below the minimum because of the shortage of work.

The unions suggested that a pension scheme should be introduced, to provide the older men with an incentive to retire. Although the employers thought " the time was not opportune" for this, they have agreed to consider the proposal. There is at present a lower guaranteed rate for men aged 65 to 70. The employers were doubtless influenced by considerations of renewed shortage of manpower as soon as the time lag imposed by round-the-Cape diversions after the sudden closure of the Suez Canal comes to an end. The acute shortage of ships, due to requisitions, may have a more lasting effect, though this may also end when the United Nations force takes over from British and French troops. In so fluid a situation the employers' wish not to reduce available labour too drastically is understandable.

Holidays and the I.L.O.

It is not often that this country, irrespective of the Government in office, rejects a recommendation from the International Labour Office. Yet this has occurred in the case of a suggestion on holidays with pay. The I.L.O. recommended in 1954 that all employed persons shall be entitled to an annual paid holiday of not less than two working weeks every twelve months. The Government is fully in agreement with the idea in principle but it does not wish to accept formally such a recommendation which would involve enforcing acceptance in industries where voluntary efforts to achieve such a standard had broken down.

Disagreement therefore goes no further than the rejection of coercion. The decision is certainly the right one. It would be folly for any Government in this country to enforce paid holiday standards on all industries without regard to the negotiating machinery and attitudes of the employers and unions involved. The Government goes as far as is necessary by setting a standard for its employees in these matters which, if not the highest, is a good average compared with industry as a whole.

The effort to set an international standard in this matter, however, underlines once again the wide differences in local practice in such matters over the world. It draws attention to the wide gap which exists between conditions of work in highly industrialised countries and those in the under-developed territories. It is only a matter of weeks ago that the United Nations was struggling to get agreement on measures to abolish slavery in certain areas.

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Trade Unions in Soviet Russia

Trade unions in Soviet Russia have little in common with our own. The basis for memberships is not trade or craft but industry, as in the United States. There is one union for each industry and membership extends from the deputy-minister in charge to the lowest paid worker, irrespective of trade, profession or status. It is voluntary, but the advantages and benefits accruing to members are such that few would elect to stay outside. The main task of the unions is to put over government policy and to encourage members to fulfil the national plans for industry. In this respect they are a means of communication between the central government and the worker, however remotely located he may be. The unions are responsible for the political education of members and they function more as corporate political commissars than as pressure groups fighting for improvements in the wage rates and working conditions of their members.

Each union member pays 1 per cent. of his or her earnings into union funds and each establishment makes an annual lump-sum payment out of retained profits. This relatively very large income enables the unions to meet their own expenses and to finance—to the extent of 70 per cent. or more of total cost—facilities for prolonged medical treatment or convalescence available in the form of rest homes and sanatoria.

This information was brought back by the British electricity supply delegation, led by Lord Citrine, which spent three weeks last spring visiting the Soviet electricity supply industry. It was given in a lecture delivered to the Instititution of Electrical Engineers in London last week by Mr. J. Eccles, deputy chairman (operation) of the Central Electricity Authority and past-president of the Institution. Information given by Mr. Eccles on wages, incentives and working hours is discussed in the following note.

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Wages and Incentives in Soviet Russia

In Russia the wage structure of each industry is centrally determined as are, each year, the amounts available for wages and salaries. Estimates are prepared by the Ministry concerned, vetted by the State Planning Committee (GOSPLAN) and submitted to the Government for approval. Once they have been approved they become " the economic bible " for the next 12 months. The global amounts, based on basic wage rates and salary scales for the various grades and on the piece work and bonus earnings necessary to produce the desired output, are what is considered " appropriate to the national output and the national economy." Senior trade union leaders are parties to the estimates and once these have been translated into wage rates in the individual establishments " there is no room for further discussion."

Mr. Eccles emphasised that there is complete equality of the sexes, in pay as well as conditions of work. Elaborate nursery facilities and home help are available. As a result women constitute an important proportion of the labour force, e.g., 40 per cent. of power station operators. The incentives to higher output are a mixture of the carrot and the stick. Piece-work and output bonus payments amount—on an average—to about 40 per cent. of the pay packet, although it is possible to double basic pay. The latter is based on job evaluation and related to length of service. Piece-work and bonus can be earned only when the worker or group is productive. If a boiler or turbine breaks down no bonus is paid until it is restored to service: " One effect of this practice is that the operators assist and encourage the maintenance staff to minimise the period of outage."

The length of the working week is normally 46 hours, including six hours on Saturday (less in exceptionally arduous jobs). Overtime working is not permitted, except in very exceptional circumstances, such as a serious accident. Shift work is the rule wherever the process requires it. There is no extra pay for night or Sunday working: when the latter occurs equivalent time off is given during the week. Non-contributory pensions, amounting to half the basic salary or wage, are paid at pensionable age (normal, 55 for men, and 50 for women) whether or not the pensioner continues to work. Many continue to work as long as possible.

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Management as a Discipline

Lt.-Col. Urwick's Elbourne Memorial lecture, given under the auspices of the Institute of Industrial Administration and called " Management Studies and Training for Managing," deserves to be widely read. It has two aspects. There are first of all its basic assumptions about which there will be some disagreement. There are secondly the deductions from them with which few will disagree—if they accept the assumptions. Col. Urwick argues that the management revolution has happened and that the professional manager is here as a long-term social phenomenon in the place of the old-fashioned " entrepreneur." Granted this, he argues that training for managing is a genuine intellectual discipline which should have full academic recognition at the older universities.

This is a bigger problem than he suggests. So far as the basic assumptions are concerned, it will be generally agreed that the professional manager is here to stay and that companies compete with vast research and financial resources controlled by gifted administrators rather than with the shrewdness of individuals running small units or by the intuition of gifted amateurs. All this may be so but it could go too far.

On the question of accepting managing as worthy of identity as a separate academic discipline, the protagonists are, to some extent, with the technicians against those trained in the Arts faculties, but they have to prove that managing can be taught in the late formative years as an intellectual discipline in the same way as applied science and mathematics can. The answer is surely that the theory and principles of managing must first be further systematised.

XUM